CHEMICAL
& METALLURGICAL
ENGINEERING

A Little Homily on
The Brooklyn Strike

AS THESE lines are written the Borough of Brooklyn is tied up tight on account of a strike of the street railway employees. They were under agreement not to strike—and the Mayor of New York went to their meeting and took from them a pledge to withhold all action until he should have had a conference with their employers. His Honor is a comedy character whose ambition seems to be to make the laborin' man feel sure that the Mayor is with him, right or wrong, no matter what he does—as long as he belongs to some union. Unless he has a big organization with many thousand votes behind him he is not a laborin' man—down at City Hall. At 2 o'clock in the morning when the night gang left work they had another meeting of their own, and they voted to strike, despite the previous resolution at the general meeting, because somebody is said to have said, which it is admitted was not true, that a number of men had been discharged. Then those who voted against the measure at the general meeting followed the strikers out. Now chaos reigns and brickbats fly.

This speed on the trigger, this German military principle of smashing up everything and making the results as *schrecklich* as possible in order to give emphasis to an opinion, is both expensive and, in the long run, bound to be unprofitable. Now to be a street-car conductor is to engage in a respectable and honorable calling. The intellectual demands may be slight, but some of us do not respond successfully to intellectual demands, and it is well for the world that there are plenty of jobs that do not require the burden of thought. But a respectable and honorable calling does not warrant either one man or a thousand of them to throw a million people into misery and to rob them of their chance to gain a living. Surely the world is neither so stupid nor so bad as to make it necessary to paralyze a whole community every time a number of persons engaged in similar employment want something.

What we need is the application of the doctrine of relativity to life. Relativity teaches us first to consider the dimensions of ideas, and then to compute the effect of their application. That is EINSTEIN'S procedure, and it is a very good one. We talk of collective bargaining, and most of us are disposed to favor the abstract idea, but isn't it time we began to think of what we mean by collective bargaining? What is bargaining? It means to negotiate beforehand; to trade. Its dimensions which we must study, in order to understand the effects of bargaining, are service, or goods, and money. Bargaining means bargaining whether done by two persons or by many. Force or compulsion does not enter into it, because, as soon as it does, bargaining ceases. If A has a house and B wants to buy it, they may bargain to reach an agreement and sale, but if B knocks A on the head and threatens to keep it up until A turns over the house to him at the price he wants to pay, we cannot call it a bargain. A strike is not a part of collective bargaining; it is compulsion, and compulsion inhibits bargaining. Discharging one man or locking out a thousand is not bargaining, either. It is also compulsion.

We are in favor of rapid and effective punishment of the employer who exploits labor; who tricks the men that work for him, or even who does not recognize his great obligations to those who cast their lots with him and throw their lives and fortunes into his enterprise. We believe that every employer is in bondage to his obligations and that the man who is unfair to those who work under him should be deprived of the privilege of administering affairs that involve the employment of men and women. But we are equally convinced that the man who works with his hands by the day is also in bondage to his obligations. And if many of them form a union the union also has obligations, not only toward its members but to the general welfare. The doctrine of relativity applies here too, but we forget it in practice, and so, often, do the strike leaders. Just because we sport a union card is no reason why we should think we have privileges which are denied to others. Neither this nor the election to executive office by a board of directors will release us from our obligations.

Relativity teaches us this, and it is very sound philosophy. We need more of it; and more quantitative thinking. Whenever the Rule of Wrath begins we lose our count, and then there is the devil to pay. Should we not profit by the example of Germany?

Chemical Industries
Need Government Help

MORE recognition of the domestic chemical industry on the part of the Government is being demanded. Chemists from all sections of the country are letting it be known that they feel that the Government has a real obligation to this industry, whose recent expansion has been so notable. At present there is no Government agency with an appropriation sufficient to be of material help.

There is a great deal of research as well as the gathering of information concerning industries which can be done successfully only by the Government. The general recognition of that fact has resulted in the constant upbuilding of this governmental activity until certain industries are very well served in matters where confidential information can be submitted to the Government by individuals so that all may profit by the reliable statistics which can then be compiled. In the same way the Government has taken up problems in research which are of general application. Most of these are

problems which a small concern could not afford to work out for itself.

While some chemical work is done by the Bureau of Standards and the Bureau of Chemistry, it has been for the most part along specialized lines. A large portion of the work at the Bureau of Chemistry is on food problems. At the Bureau of Standards, as the name indicates, most of the chemical work has been done with the view toward standardization. The general impression conveyed by letters reaching Washington seems to be that the chemical division of the Bureau of Mines should be expanded to take care of the chemical industry in the same way that the petroleum and mining work is conducted. As is well known, the Bureau of Mines is a part of the Interior Department, which is the great engineering branch of the Government.

The chief demand at the present time seems to be for the compilation of information concerning raw materials of the chemical industry, uses for waste products and means of obtaining greater efficiency within the industry. There is also an insistent demand for research, especially in the development of uses for byproducts which now are going to waste. Whether the Bureau of Mines could handle these investigations, except as they involve the use and conservation of minerals, is a question, yet in view of the admitted importance of an American chemical industry to America, it is reasonable to agitate for active governmental interest in its behalf.

Future Lines of
Progress in Steel

THE steel industry still finds itself in the position it has occupied since it came into being: in need of making expensive improvements. There is always something more to be done. The steel manufacturer never gets to the position of feeling himself "on Easy Street" with nothing to do but operate his plant as it stands and make the money.

Building of byproduct coke ovens has had a wonderful vogue, as such things go, but with all the additions to coke-making capacity the market for Connellsville furnace coke for two months past has averaged about $18 per net ton at ovens. Those who held back from building byproduct ovens thinking that what others were doing would make beehive coke cheap have been completely disappointed. There is more money than ever in byproduct operations, and those who have byproduct ovens have occasion to carry farther their operations of winning byproducts.

The course of the pig iron market has shown that a steel works is not safe in depending upon the market for supplies. When, years ago, the major part of the merchant pig iron made was used in making rolled steel, the steel industry made the pig iron market. Now the pig iron market is made by the foundries, chiefly the gray iron and malleable foundries, but a considerable part of the bessemer and basic iron made for sale is taken by steel foundries. The remaining works making rolled steel will in most cases find it desirable to build their missing blast furnaces.

As a very large consumer of fuel the steel industry has had forced upon it the fact that it must go in for much greater fuel economy in future, for while coal will decline from the particularly exorbitant prices lately ruling, it will never be relatively as cheap as it was before the war. In addition there is the changed outlook regarding supplies of oil, which the steel industry can hardly count upon as it recently thought it could.

In the matter of introducing labor-saving machinery and devices the steel industry has as much before it as at any time in the past, for high wage rates have come to stay and in addition there is within the discernible future the elimination of the 12-hr. day, which means that in some cases a given improvement will save the work of three men in the twenty-four hours instead of the work of two.

The steel industry has only begun to make special steels. The demand for special steels, suited to the particular purpose, has grown while it slept. For a year past there has been a "sellers' market" in steel and the buyer hesitated to express his new-found wants, being glad to accept almost any kind of steel, but no such condition can last indefinitely.

Possibly in the quality competition that is to come the steel industry will go considerably farther in the matter of vertical integration, carrying its products to a greater degree of finish. Hitherto there has been a strong disposition on the part of steel manufacturers to stop with the ordinary rolled products, carrying vertical integration backward to the minerals in the ground rather than forward into the manufactured wares, but it seems rather unscientific for rolled steel producers to sell large annual tonnages to single consumers, who in turn have but few customers and whose operations are more or less simply forming operations, when success depends as much upon the character of the steel purchased as upon the skill with which the relatively elementary forming operations are conducted.

Whether the steel industry will become more scientific in marketing its wares remains to be seen. It has the much criticised "open contract," but it has been running as full as it could up to date, while the woolen mills, which have the "binding contract," have been largely closed. One cannot predict what the steel market will do, when this year it has exhibited a phenomenon no one would have believed possible, that of about 45 per cent of the production being sold at a set of stabilized prices now seventeen months old, while the rest has been sold practically at what it would bring.

Chairman Bancroft's Report
To the National Research Council

WHENEVER Professor WILDER D. BANCROFT writes or says anything it is worth reading or hearing. He has been for the past year Chairman of the Division of Chemistry of the National Research Council, and his annual report of the Division was published in the September number of the *Journal of Industrial and Engineering Chemistry.* The restriction of the chairmanship to a single year's incumbency was designed to provide for the incidence of the greatest variety of tried and experienced directing minds upon chemical research. Instead of systematizing the organization until it runs itself while everybody does routine work, the very opposite is provided for, and this is as it should be. It is easy to kill research with too much system, although in selecting Dr. BANCROFT for the post all possibility of dullness was avoided. He is a man of infinite variety, who couples with this engaging quality the accomplishment of profound scholarship and the habit of thoroughness. As for the work done, he refers

to the reports of the chairmen of the various committees which have already been published. He then proceeds to indicate questions that need answer.

An interesting point which he brings out is the work which is needed and called for along the borderland between chemistry and one or more other sciences. "The conditions at Washington," he says, "are peculiarly favorable for such a development, because the chairmen of the different divisions are under the same roof and can discuss matters informally in the most satisfactory manner. It is easy to see that if we bring together, for instance, men representing three different sciences involved and if each man knows a quarter of a given problem, then the problem is three-quarters solved before any further work is done." And he proceeds to note some of the borderland problems which interest him.

In baking, the American Institute has recently been founded with Dr. H. E. BARNARD in charge and Dr. MORRISON to direct research. The Advisory Board consists of Messrs. BANCROFT, BARNARD, CLOWES, HENDERSON, McCLURG, McCOLLUM, MENDEL, MENDENHALL, MORRISON, MARLIN, PRESCOTT and TAYLOR. We congratulate the Institute of Baking on such a distinguished and capable selection of advisers. One of the unanswered problems has to do with the nature of gluten. A high gluten content seems to provide generally for superior bread, but the rule has too many exceptions. Bakers refer to "strong" and "weak" glutens, and yet the different glutens appear to have the same chemical composition. It is not known whether the differences are due to structure or to the presence of salts. Staleness seems due to a displacement in the distribution of the water content between the gluten and the starch. To prevent this is another problem in colloid chemistry. Again, why is homemade bread better than baker's bread? Why is French bread better than American bread and Vienna bread better than the French? Thus far the microscope does not appear to have been used in the study of bread. What will it tell?

The problem of stimulating pine trees to give a better yield of turpentine is discussed at length, the work of TSCHIRCH, HERTY and Miss GERRY is considered with a view to getting more light—and more terps and gum. The plan involves the study of a botanist, a microscopist, an organic chemist and a colloid chemist. Then he proposes the application of similar research to the collection of rubber, and finally to shellac.

The study of protoplasm is recommended in connection with the study of emulsions, and the further study of war gas problems is important in that it opens the way to the study of the chemistry of blisters and burns and also leads up to the important general subject of chemotherapy, which calls for joint research by medical men, biologists and chemists.

Other investigations recommended have to do with special sugars, with the normal weight of men and the search for whatever the regulator may be which determines and controls his normal weight, structural colors, sedimentary rocks—just as the Geophysical Laboratory studies igneous rocks—clay, pressure phenomena within the earth, thunderstorms, surface colors, Brownian movements, adsorption of gases, criteria of purity, quicksands, metallic luster, and educational tests.

Dr. BANCROFT says that the Division is still "long on promises and short on results," and he mentions it apparently with regret. We hope on the other hand that its aspirations will always be greater than anything that is or even can be achieved. This is only possible when men of inspiration lead it.

Pyrolytic Distillation and
Pyrogenesis of Hydrocarbons

NOW is the time to choose between the terms "pyrolytic distillation" and "pyrogenesis of hydrocarbons." If one expression is not wide enough in scope for technical purposes, both should be used after precise definitions have been established. W. A. HAMOR, co-author with Dr. BACON of the best treatise on petroleum, is sponsor for "pyrolytic." Etymologically it is a gem. It will make a good team mate for its brother adjective electrolytic, while pyrolysis can associate with electrolysis among the nouns. The second term was put into use in England after BERTHELOT demonstrated the fact that acetylene could be polymerized into liquid hydrocarbons under heat and pressure. That our so-called petroleum cracking process does not come under this class of reactions is amply demonstrated elsewhere in this issue by Mr. PADGETT. In our opinion pyrogenesis should be limited to cases when the benzenoid hydrocarbons are produced.

At a future and probably not distant date we shall hear of pyrochemists. The chemical phenomena of heat well merit special training on a similar basis with electrochemistry. Demands for such training now exist in the petroleum industry and are being met about as satisfactorily as were the unanswered calls for electrochemists voiced by DAY at Niagara sixty years ago.

Cook's Tours à la
Mining Engineers

WHEN a technical society—or rather a few fortunate members—go touring, as recently did the Mining and Metallurgical Engineers, they usually return with at least two uniform impressions. One is that they have been spending several days with some very fine people, getting acquainted as would otherwise require years in our modern cities, and the other is that they need quantities of rest and quiet after the exhausting hospitality tendered by the various hosts en route.

Indeed, if the trippers realized what was before them when they start as well as they know what happened to them after it is all over, they could easily be organized into a temporary union with a principal "demand" for a 12-hour day (maximum). Anyone who crawls into a berth at midnight after attending a banquet, only to travel 200 miles and be awakened by the porter at 6:15 the next morning so as to have breakfast and be ready for another 15- or 16-hour "shift" starting at 8 o'clock, has reason to exclaim with the poet, "A truce to so much hospitality!"

Doubtless, though, unionization will fail. We shall have to put ourselves unreservedly in the hands of our friends. But at the same time we hereby serve notice upon the Secretary of the Institute that he will be held personally responsible for arranging it in the future so that in case one day ends in a midnight "athletic contest" the next day may not start before noon! Or, if the next day's hosts insist upon a 10 o'clock start, to demand an earlier athletic contest—for we certainly can't miss anything so exciting!

HUDSON RIVER MILL OF THE INTERNATIONAL PAPER CO.

Fall Meeting of T.A.P.P.I. at Saratoga

Résumé of Special Papers Presented at the Meeting of the Technical Association of the Pulp and Paper Industry—Visits to the Paper and Pulp Mills and Other Plants Allied to the Paper Industry—Social Features—Abstracts of Speeches

THE fall meeting of the Technical Association of the Pulp and Paper Industry was held at Saratoga Springs, N. Y., Sept. 1 to 3 inclusive. The meeting was called to order in the Casino by Chairman Raymond S. Hatch, who after a few introductory remarks introduced the first speaker, Edward B. Ashton, chairman of the Chamber of Commerce. Mr. Ashton greeted the members of the association heartily and welcomed them to the hospitality of the city.

George S. Witham, Sr., manager of mills of the Union Bag & Paper Corporation, replying in behalf of the society, emphasized the appropriateness in the choice of Saratoga for such a gathering, as it was located in the heart of the Adirondacks, replete with the history of paper making. He also spoke in the highest terms of our neighbors on the north who are closely allied with us in the paper industry and who have lived for so many years in close proximity without even so much as a single modern fortification on the whole borderline. Mr. Witham also commented on the lack of foresight on the part of American paper manufacturers in the past in their wasteful manner of lumbering, and strenuously urged the necessity of concerted action in the future to conserve our present timber supply if the paper industry in this country is to remain independent of outside sources.

Improvements in the paper industry due to the application of chemical and engineering technology, and the contribution and importance of paper in the dissemination of knowledge and advancement of education were also brought out.

For the executive committee, Chairman Raymond S. Hatch reported a steady increase of membership since the annual meeting held in New York four months ago, the total membership now exceeding 602. Two members had been lost by death, George C. Sherman and Henry Earl Surface.

It was stated in the report that after long and careful deliberation the executive committee had decided to abandon the idea of publishing a trade journal through the Tappi Publishing Corporation. Instead of this the association is to undertake the publication at least semi-annually of a volume of proceedings, transactions, abstracts of literature and original articles. The committee said that a beginning has been made by the publication of a revised edition of the paper testing committee's report. The work bears the title "Paper Testing Methods," and constitutes a practical treatise on approved modern methods for testing papers by microscopical, chemical and physical means. The work is illustrated and one of the chapters deals with the fibers used or proposed for use in papermaking.

The committee recommended an increase in the annual dues of members and associate members to $25, the subscription for juniors being allowed to remain at $5 as at present. As this necessitates an amendment to the constitution and bylaws, unanimous consent was asked and granted for a suspension of the rules. The amendment was adopted by unanimous vote.

In conclusion the executive committee expressed hearty appreciation and thanks in behalf of the association to the paper manufacturers of the Hudson River and associated industries for the splendid entertainment and educational features which had been provided for the fall meeting.

After various committee reports the remainder of

the first day was devoted to the reading and discussion of the technical papers.

R. E. Lofton and M. F. Merritt of the Bureau of Standards, Washington, gave an interesting paper on a quick method of determining the presence of sulphite fiber in pulp. This method depends upon the selective action of certain dyes for sulphate and sulphite fibers.

New Felt-Cleaning Device

In a paper on "New Felt-Cleaning Device" C. A. Woodstock discussed a new device for cleaning the felts of paper machines without the necessity of shutting down the machine.

This suction effect is adjustable, and can be applied to the felt, which has previously been treated with water or some other cleansing solution to loosen any included material, and clean it without interfering with the operation of the machine. This saves considerable time, effects a large saving in cost and increases the production greatly.

The results in economy on three Fourdrinier paper machines running on newsprint at a speed of 650 to 675 ft. per minute were an increase of production of

SKETCH OF EMMET MERCURY BOILER

12½ per cent, increase of speed 7⅓ per cent and an increase of efficiency of 5⅓ per cent.

Boiler Room Efficiency Increased by a New Mercury Boiler

Probably the most interesting subject discussed was the mercury boiler designed and described by W. L. R. Emmet of the General Electric Co.

In this device Mr. Emmet has made use of the physical properties of mercury to increase the boiler efficiency. He has designed a mercury boiler in which mercury vapor under a pressure of 10 lb. is first used to drive a mercury turbine and the exhaust mercury

vapor is condensed in a surface condenser under a vacuum. In condensing it gives up its heat of condensation to the cooling water, which now becomes hot enough to act as a source of heat energy in an ordinary steam boiler. This steam drives a steam turbine. Great care must be taken to have all mercury lines and joints perfectly tight, as mercury is very poisonous, especially in the vaporous state.

According to *Power*, Mr. Emmet claims that by the addition of this device to an assumed good modern power station, with an increase of 15 per cent in the amount of fuel used, the same amount of steam can be supplied to the steam turbine as under present conditions, and the mercury turbine will generate power equal to about 66 per cent of the power generated by the steam turbine. This results in a gain in station capacity of approximately 66 per cent with an increase of only 15 per cent in the amount of fuel required.

Curtailing Bleach Consumption by Adding Sulphur to Digester Liquor

George K. Spence gave a summary of the results of his experiments on the effect of added sulphur to digester liquor on curtailing bleach consumption. Since it requires 11 lb. of sulphur per 100 lb. of stock to save 92 lb. of 35 per cent bleaching powder there would be very little advantage in its use under ordinary conditions. However, it is claimed that increased strength is produced by its use in the digester liquor, which will furnish material for further experiments in order to determine the extent of this increase.

Automatic Continuous Mixing System

A new automatic method of handling paper stock so as to economize on floor space, labor and power was presented by E. J. Trimbey.

Ground wood and sulphite are furnished continuously, either by gravity or by pumping to their respective compartments of a double vat. Each compartment is provided with an overflow dam and a float valve of special design for maintaining a constant level in the compartment regardless of the rate of flow of stock. Mounted in one end of this double vat is an outlet spout communicating with both the ground wood and the sulphite compartments, and so arranged with a separating partition and an adjustable top that the cross-sectional areas for the outflow of ground wood and sulphite will give the desired proportion of each, and at the same time the total flow can be varied to meet the changing requirements of the paper machines.

In addition to being adjustable for both total volume of flow and relative proportions of ground wood and sulphite, the outlet spout has valuable regulating features which automatically compensate for minor variations in the consistency of each. With a constant head and varying velocity and consistency, a proper design of apparatus can be made whereby the increase in velocity of the paper stock flowing through it can be made to counterbalance the increase in consistency, so that within a given consistency range there will be a constant rate of discharge of dry stock per unit of time.

C. A. Allen read a paper on the Automatic Cooking Control for Sulphite Digesters, which will appear in a subsequent issue.

H. P. Baker, secretary of the American Pulp and Paper Association, as toastmaster at the T.A.P.P.I. ban-

quet, spoke of the part chance had played in the past in the paper industry and how the association was fast doing away with chance and substituting facts in its place. He also emphasized the greater need for a broader knowledge of the paper industry as a whole among the general public.

Other speakers were L. H. Shipman, of the Spanish River Pulp & Paper Co. and chairman of the technical section of the Canadian Pulp and Paper Association, and George Sisson, Jr., president of the American Pulp and Paper Association. Mr. Sisson complimented the members of T.A.P.P.I. on their efficient service and spoke of the spirit of modern business, emphasizing the spirit of co-operation and the tendency to get together to solve the common problems. He also spoke of the ever-increasing demand for paper and of the untold value of research to the industry.

VISITS TO PLANTS

Thursday was devoted to visiting the various paper mills located in the immediate vicinity. Automobiles took the members to the Hudson River Mill of the International Paper Co. at Corinth and the Finch Pruyn Co.'s plant at Glens Falls, where the members, divided into small groups, were conducted by guides through the mills.

HUDSON RIVER MILL

This plant is situated on a water site which gives an 84-ft. head which is used in two stages to develop approximately 20,000 hp. In addition the plant is equipped with five 520 B & W boilers equipped with Coxe stokers for handling fine anthracite. In the paper mill there are Curtis mixing tanks, nine news and one wrapper machine. The wood room has one Paulson drum, six Portland drums of twenty-five cords per hour capacity. Ground wood mills have fifty-six grinders, six improved first screens, twelve flat second screens, twenty-two deckers and twenty-eight presses. The shredding system consists of Jeffrey shredder, Mitts & Merrill shredder and three Allen mixers. There was stored in the yard for use during low water 22,000 tons of lap ground wood pulp. The pulp is carried into the mill by a belt conveyor, which drops it into a Jeffrey shredder, whence it is taken away by another conveyor to the Allen mixing system. The daily production of the mill is 275 tons news, 12 tons mill wrapper, 60 tons sulphite and 320 tons ground wood.

FINCH PRUYN CO.'S MILL

This plant, located at Glens Falls, N. Y., is a ground wood and newspaper mill. It has a total water-power development of 15,000 hp., the rating of the grinder wheels at an average head of 39 ft. being 12,000 hp. There are twenty-five 27 to 32 x 54-in. grinders, which have a maximum production of 200 tons in twenty-four hours. Production for 1919 was 32,061 tons. Grinding is done by the Hall's process method. Tailings run under 2 per cent. The mills make newsprint and hanging. There are three Fourdrinier machines, one 90 in., one 116 in. and one 148 in. with 70 ft. wires; three presses and thirty-two 34 to 48-in. diameter driers. These machines run at speeds of 650 to 675 ft. per minute and at present average of standard newsprint is 775 to 790 lb. per day per inch trim. Average for July was 784 lb. All machines are equipped with Woodcock & Walker felt-cleaning system.

VISIT TO PAPER MACHINERY MANUFACTURING PLANT

A short recess for luncheon as guests of the Hudson Valley Manufacturers at the Glens Falls parish house was followed by a trip through the Sandy Hill Iron & Brass Works, where the members had an excellent opportunity to see the paper machines and screens in the process of manufacture.

UNION BAG & PAPER CO.

A plant capable of turning out 14,000,000 bags and sacks daily next took the attention of the visiting members. This factory contains thirty-four printing presses and complete equipment for composing, stereotyping, etc. All printing is done from stereotypes, no original type being used. There are twelve rotary suction presses with automatic feed and counting attachments printing in one and two colors; fourteen platen or hand-feed presses and eight rotary web presses for printing bags in rolls. Total capacity, 1,750,000 impressions daily.

The machine room of the factory contains forty-five machines, all of which make square and flat or old-style grocery bags. The smallest of these machines, making ½-lb. and ¼-lb. bags, will turn out as many as 225,000 bags per day.

In the finishing department the bags were tied in packages of 500 each and wrapped in bundles of heavy kraft paper for shipping. The largest machine room had eighty machines, all making the automatic or self-opening style of grocery bag in sizes from ¼-lb. to 35-lb. The last room visited was equipped with fifteen machines for making various sizes and weights of sacks for flour, charcoal, poultry lime, fertilizers, etc.

Across the river stands the big Fenimore pulp and paper mill of the company. This plant uses the sulphite process and is a model of neatness. The logs are floated to the chipper and the chips carried by belt conveyors to the four digesters, which have a capacity of twenty-five cords each, when they are cooked for seven to eight hours. The pulp from the digesters is then pumped to the mixers and screens to be made into paper.

A three-hour delightful sail on the beautiful Lake George, where the guests were entertained with a concert given by the Union Paper & Bag Corp. band, followed by a luncheon, completed the second day.

MEMBERS VISIT G. E. PLANT AT SCHENECTADY AND FELT PLANTS AT ALBANY

Wednesday was devoted to visiting the General Electric Co.'s plant where the society was conducted in small parties through the mammoth plant. Special interest centered in the new mercury boiler and in electrical machinery designed for the paper industry. After a luncheon in the dining hall, at which General Manager Erben welcomed the visitors, the rest of the day was consumed in visiting the felt plants of F. C. Huyck & Sons and the Albany Felt Co. In these plants the process of manufacture of felts for Fourdrinier machines was shown from the raw wool to the finished product.

About 350 of the 600 members attended the convention, which was the largest and most successful gathering yet held. It was with a feeling of great satisfaction for the results accomplished and gratitude to the officials of the various paper companies for their generosity and cordial hospitality that the meeting closed.

The Separation of Air Into Oxygen and Nitrogen

Use of Oxygen in Chemical and Metallurgical Processes Retarded by Inefficiency of Existing Systems for Air Separation—Power Requirements for Theoretical and Existing Systems—Liquefaction of Simple Gases — Condensation and Distillation of Mixed Gases — Improved System for Air Separation

BY FRED E. NORTON

THE industrial use of oxygen gas for welding and cutting has been developed almost entirely through a distribution system involving the use of steel bottles as containers for the highly compressed oxygen. On the other hand, the fixed nitrogen industry demands that the nitrogen be produced immediately at the fixation plant, and hence the separation process becomes a part of the fixation system, because of the enormous volumes of gas to be handled.

RESTRICTIONS OF PRESENT PROCESS

It is evident that if oxygen is to be used for large chemical or metallurgical processes, it will be necessary to install the air separation plant adjacent to the point of application of the oxygen. It is out of the question to expect that bottles or other containers can be used where such immense masses of oxygen have to be considered. Where bottles are employed the charges for interest, demurrage and handling so far exceed the present plant cost of the oxygen that the latter item is almost negligible, and hence the manufacturers are not greatly concerned about the plant cost of oxygen, since it is not a deciding factor in respect to sales. Oxygen is demanded, and the sales price is many times the plant cost. The purchaser's interest need not be considered in this respect.

The case is far different if oxygen in bulk is in question. The development of the application of oxygen in many chemical as well as metallurgical problems is now reduced to the simple one of cost. There is no question as to the desirability or feasibility of applying oxygen to oxidation processes in general, such as the burning of sulphur, the oxidation of ammonia to nitric acid, all smelting operations, and the manufacture of water gas.

FEASIBLE COSTS

The industrial applications of oxygen depend very largely on the cost of the oxygen.

A fair estimate may be made of the value of the oxygen by considering the cost of burning one ton of carbon to CO_2 or to CO.

For high-temperature work, such as iron blast furnaces, the bulk of the coke is burned to CO only.

Taking a base cost of oxygen at 1c. per thousand (16 lb. of oxygen per 12 lb. carbon), we have 33.63c. for the oxygen to burn one ton of carbon (2,240 lb.) to CO, say 34c. If the combustion is complete, the cost would be (32 lb. oxygen per 12 lb. carbon) 67.26c. to burn one ton of carbon to CO_2, say 68c.

It is estimated that for a production of, say, 4,000 cu.ft. of oxygen per minute the cost of oxygen may be reduced to, say, 6c. per thousand (including all fixed and daily charges).

The cost of blowing a smelting furnace with pure oxygen would, therefore, amount to $0.34 \times 6 = \$2.04$ per ton of carbon burned. However, it would probably be advisable to use a blast of, say, 35 per cent O + 65 per cent N of which half the oxygen would come from air to be mixed with the oxygen blast. We may, therefore, estimate that the oxygen blown to the furnace would come equally from normal air without cost, and from a separation plant, at, say, 6c. per thousand, or, say, average cost 3c. It would, therefore, cost $3 \times 0.34 = \$1.02$ for the oxygen to burn one ton of carbon to CO or, say, $2 to burn one ton of carbon to CO_2. These figures are easily seen to be within reason, and include all interest and depreciation charges.

For smaller plants, the cost would rise, and on the scale of existing plants, a cost of perhaps 25c. per thousand would be reached. This is because of the heavy ratio of plant charges for small capacities, and also because in any thermal process the loss per cent diminishes rapidly as the size increases. However, the new system has the advantage in all except the laboratory sizes. It may be said that the advantage increases rapidly with the capacity of the plant, and there is no limit as to size in sight.

A cost of 25c. per thousand for oxygen means $8.50 for the combustion to CO, or $17 for complete combustion (per ton of carbon with pure oxygen). These figures would be halved in the case of 35 per cent O + 65 per cent N mixed blast.

The present indications are that 25c. per thousand is about the limiting cost. For ultimate economy 65 per cent nitrogen is too high.

NEW FIELDS OPENED

Returning to 6c. basis for oxygen. What an enormous field lies open before oxygen at such a cost! The smelting of manganese and chrome, as well as high silicon and carbon irons, is most directly affected. With control of the oxygen content of the blast, and much higher temperature (and available heat), come an approach to electric furnace conditions, without excessive cost.

The possibility of making steel direct from the ore is not to be disregarded. In this connection, a whole new field lies open in the making of carbides by direct heat in an oxygen-blown furnace and in the treatment of these carbides with nitrogen.

The whole nitrogen-fixation industry may very possibly depend on the cheap production of carbides by oxygen-blown furnaces, independent of cheap power, or pure materials of extraordinary cost; and in unfavorable localities. The disintegration of such slags by gas blast instead of by grinding is an incident to this development worth consideration. The developments may take many years, but they cannot begin until a cheaper source of oxygen is available, and this first step is assured in the immediate future, the technical **basis being completely** solved.

Turning to the applications which are already well developed, the welding of large masses of metal is hampered by the necessity of using acetylene gas to *save oxygen*, and the reduction in the cost of oxygen will permit the use of cheaper *gas*. It may be expected that even the acetylene will be indirectly cheapened by the more economical production of carbide by oxygen-blown furnaces. The welding of tubes and large structural parts thus assumes a new aspect as to cost.

, In the matter of gas manufacture, there is the possiblity of driving a water-gas producer continuously. A producer may be fed with raw coal, and if oxygen and steam be mixed in the proper proportions, a continuous partial combustion of the carbon to CO (with a small per cent of CO_2) will keep the remainder of the fuel at a high enough temperature to decompose the steam into hydrogen, and the oxygen thus released will combine with the incandescent carbon to furnish CO. With such a producer, a high quality of gas may be made, quite suitable for use in stoves and incandescent mantles. In view of the rising cost of city gas, this is a most economic advance. It is easy to calculate the approximate cost of gas making, and even if the base cost of oxygen be doubled or tripled, a very great saving is inevitable.

The smelting of all volatile metals, such as zinc, is an obvious application, and many uses of cheap oxygen will appear in this field.

In the manufacture of sulphuric acid, nitric acid, ammonia, and in fact the whole of the chemical industry, oxygen is the live element which carries all else with it. There is no need to multiply the examples of useful application, but there is great need of a better understanding that the cheap oxygen is within reach and that plans for the immediate future should consider this fact.

EXISTING SYSTEMS INEFFICIENT

The costs stated are so far removed from any possibility with the present systems that it may appear that some error may exist in the estimates. The very fact that such costs are possible changes the whole status of the oxygen industry, and makes it difficult for those closely engaged in the oxygen business to credit the figures. It can only be said that the estimates have been very carefully made by means of accurate data, and that the basis of the liquefaction system is one which has a theoretical efficiency of unity.

On the other hand, the existing systems, to which comparisons will unavoidably be made, have a basic efficiency of less than 10 per cent. The demonstration of this fact is not complicated—it is so extremely simple that one is unwilling to accept the evidence of plain facts, because the existing systems give unavoidable prejudice. If the waste of power is kept in mind the whole will be clear.

It is evident that if the very low efficiency of existing systems is due to a mistake in the choice of physical conditions the probability of error of judgment lies heavily on the advocates of such defective systems. It is not to be expected that enthusiastic indorsement will be given to a clear proof of the mistake in fundamental physical conditions which are essential to high efficiency. Unavoidably, the exposition may appear to reflect unfavorably on the judgment as to what may afterward appear to be obvious facts. We wish to emphasize the fact that there is a fundamental error in the separation cycles as developed along the lines of the old processes, and that these processes cannot be improved by "doctoring" them here and there. The basic defects are:

First, the total destruction of the primary work of compression. This is not a necessary requirement of nature, and results from bad thermodynamics.

Second, a false step in the distillation of the air—i.e., the introduction of outside heat into the still.

RADICAL CHANGE REQUIRED IN EXISTING PROCESSES

These matters are of extreme simplicity in themselves —they will be demonstrated in another place. Our object now is to point out that the present estimates are based on new developments, and the figures for cost must not be considered as arising out of trivial modifications of existing processes. We admit at once that no existing system can produce oxygen at a cost which will permit of commercial use in metallurgical processes. By the application of proper thermodynamic steps (which are radical) the existing apparatus can be made to give costs approaching our estimates. The systems would then be distinctly new and have been thoroughly protected by broad patents.

DEVELOPMENT PROSPECTS

In view of the wide application of the process, it has been determined to keep it free from exclusive control and yet to preserve the incentive of sufficient control to encourage development in as many lines as possible. No operating system has been constructed, and it will be realized that since high economy may only be reached with a large plant, it is a serious financial undertaking. The history of such developments in the United States is not encouraging. The telephone, telegraph, electric light and air brake are typical of purely American ventures requiring small capital in the beginning and large and steady returns from the first. The exception of the Atlantic cable is remarkable. The railroad, steamship, deep mining, steel making, the gas and oil engine, the airplane, the aniline dye industry, the nitrogen-fixation industry and even the automobile and so many other developments are typical of European enterprise, in the middle stage of developments, if not in the earliest period. So many of these developments originated in this country and languished here for want of capital that there is ample ground, on precedent, for fear of a repetition of history in this new oxygen field. There is not an immediate possibility of great gain, in money, without investment of large sums for plant and development work. The prospect is not enticing from the stock-market point of view.

RETARDED DEVELOPMENT

While the development of oxygen production on a large scale is undoubtedly an expensive matter, the immense field which lies undeveloped constitutes perhaps the most evident attraction in sight for the adventurous and progressive pioneer in chemical and metallurgical enterprises. Granting that if oxygen be cheap enough, there are numerous applications, it may seem strange that so little has been accomplished in the direction of lower costs for the oxygen.

The situation is not a creditable one to American industry. Our path has been strictly in the footsteps of German and French pioneers, and no independent thought seems to be evident in the design or construction of air separation plants in this country. The

reasons for this conservatism are perhaps good, for apparent commercial reasons; but it is believed that it can be shown that the reluctance to strike along original lines is owing to an imperfect understanding of the real problems and not the nature of the problem itself.

It is a strange fact that the oxygen business today is practically a monopoly, though air is free to all, so the business has the great attraction that nature furnishes the raw material free of cost. Perhaps this fact has hindered development, since cheap raw materials often lead to crude methods. The secrecy which has been maintained for so long seems to be equally based on ignorance and timidity on the part of the commercial element in the oxygen business. The purpose of this article will, therefore, be to clear up such of these obscurities as may lead to at least an elementary idea of the possibility of advance in the direction of lower costs of oxygen and nitrogen and hence in the development of industries which have unbounded prospects of economic advance.

OBVIOUS DIFFICULTIES IN AIR LIQUEFACTION

In the first place, the idea that the extreme cold required to liquefy air in a counter-current system (and this is always a preliminary to the separation into oxygen and nitrogen) is a difficult and dangerous state to reach is false. This idea has been cultivated and imaginary obstacles to air liquefaction have been multiplied by those interested in the protection of existing monopolies. It is a perfectly easy matter to liquefy pure, dry air, and no unusual precautions are needed to do it with standard commercial compressors and a little copper pipe. The use of steel instead of copper apparatus is perfectly feasible, and high pressures are not essential.

The one vital preliminary, however, is always that the water vapor and carbon dioxide in the ordinary air must be absolutely removed, and it may be said that 90 per cent of the problem is solved, so far as the operation of an air system is concerned, when this has been perfectly accomplished.

Without going into details, it may be said that the preliminary freezing of the air down to, say, —100 deg. C. will remove sufficient of the water vapor to permit continuous running of the separation system without clogging or coating of the heat transfer system. By means of pre-coolers, in duplicate, and so arranged that the units are alternately cooled and thawed, the moisture removal is a demonstrated success. This problem is solved. The CO_2 removal may or may not be required, since its ice forms an emulsion in liquid air which does not interfere with an apparatus which is free from restricted passages or small pin-hole throttles. However, it may be cheaply removed by preliminary washing with weak soda or lime solutions in mechanical washers. This difficulty is serious for some types of apparatus, but trouble may be avoided either by the chemical removal of the CO_2 or by a change in the design of apparatus.

The system to be described has no restricted passages and no throttles or other mechanisms which may become clogged with water or CO_2 ice. This is perhaps the most important practical element in the whole problem.

It should be emphatically stated that clean, dry air is easy to separate. Ordinary moist air cannot be liquefied continuously, because of obstructions in the apparatus. It should also be stated that there are many other unsuspected things (solid and gaseous) in ordinary air; and provision must be made to get rid of them, or explosion and choking will occur. These are easily provided for and are matters of good design. It is in respect to such apparently trivial things that great advance is possible in the practical operation of air separation systems. Owing to the past history of the development, it is quite probable that the existing methods do not form a good basis for estimating the possibilities of improvement.

While the existing methods of air purification are crude and unsatisfactory, they are not so vitally defective as the liquefaction and separation cycles which have so far been used. It is not too much to say that this defect is so little understood, even by those familiar with the existing systems, that the argument may fall on ears deaf to the facts, because no sound basis is available to evaluate the real situation. These rather harsh statements are justified by the claims, so often made, that the existing systems do not fall far short of theoretical efficiency.

ELEMENTS OF COST

Let us see what the separation of air by liquefaction demands in respect to total cost.

First—Interest and depreciation of plant.

Second—Cost of labor.

Third—Purification.

Fourth—Power.

The first item will depend on the effectiveness of the apparatus—i.e., on per cent oxygen recovered out of the total in the air which enters the apparatus. In a minor degree, it is affected by the efficiency—i.e., the ratio of power used to theoretical power required; since the cost of machinery, such as motors, etc., will depend on the wasted power. However, this item may be set aside, since it will be shown to follow, as a consequence of the proposed improvements, that the first cost of plant will be reduced as compared with existing systems. It is not the controlling variable, though a very large element of cost of oxygen.

The second item, labor, may be set aside as practically the same for all systems.

The third item is of utmost importance, as it affects continuity of operation, and hence the production factor of a given investment. It may be reduced to a point of minor importance, as will be shown.

The fourth item is the critical one, and it is here that all existing systems fail in basic principle to realize in any way the moderate demands imposed by nature as the true cost of air separation. It is very easy to evaluate the power requirements of any existing system.

THEORETICAL POWER FOR SEPARATION OF AIR

The separation of 1 kg. of air into oxygen and nitrogen demands simply the isothermal compression of about 0.23 kg. oxygen from 0.2 atm. to 1 atm., and a similar compression 0.77 kg. nitrogen from 0.8 atm. to 1 atm. That is, the two components, oxygen and nitrogen, must be compressed isothermally at atmospheric temperature from their individual partial pressures in the atmosphere to the total pressure of 1 atm. on pure separated gases. And however much the fact may be disguised by complicated stills and interchangers, it is only this effect which the whole must, in theory, produce.

We may take 300 deg. C. abs. (27 deg. C. or 80 deg.

F.) as the temperature of the atmosphere, while the gas will be measured at zero deg. C.

Hence $W_N = 0.77 \times 0.163 \times 300 \log 1.25$
$$= 3.649 \text{ cal. per } 0.77 \text{ kg.}$$
nitrogen
$$W_o = 0.23 \times 0.1423 \times 300 \log 5$$
$$= 6.896 \text{ cal. per } 0.23 \text{ kg.}$$
oxygen
$$10.545 \text{ cal. per kg. air}$$

This amounts to $10.545 \div 10.69$, or, say, 1 hp. per kg. of air separated per minute.

Since 1 kg. air has a volume of 0.7734 cu.m. at zero C. we have $1 \div 0.7734 = 1.2931$ hp. per cu.m. air separated per min. giving 0.21 cu.m. oxygen or, say, $1.293 \div (60 \times 0.21) = 0.103$ hp. per cu.m. oxygen per hr. (2.92 hp. per 1,000 cu.ft. oxygen per hr.)

For all practical purposes, we may take 0.1 hp. per cu.m. oxygen as the theoretical power required for separation (per hr.).

Now, existing systems may produce oxygen when the air is compressed to, say, 30 atm. (435 gage). The compression of 1 kg. air to 30 atm. at 300 deg. C. abs. (27 deg. C.) requires (adiabatic 2 stage) $W_A = 2 \times 0.236 \times 300 (30^{0''} - 1) = 90.2$ cal. per kg. air, or $90.2 \times 1.293 = 116.6$ cal. per cu.m. air.

Since about 5 cu.m. of air is required to contain 1 cu.m. oxygen, and existing processes must compress, say, one-third more air than is separated, we have $116.6 \times 5 \times 1.333 = 777$ cal. per cu.m. oxygen delivered pure, or, say, $777 \div 10.69 = 72.7$ hp. per cu.m. oxygen per min. Therefore, such a plant would require $72.7 \div 60 = 1.21$ hp. per cu.m. oxygen per hr. (34.27 hp. per 1,000 cu.ft. oxygen per hr.). The efficiency would be $0.103 \div 1.21 = 0.085$, or 8.5 per cent, and surely this is not a very creditable figure for a process which may be shown to be reversible in theory.

EXISTING SYSTEMS

There are two systems in use for separating air by liquefaction and distillation.

One of these depends on the cooling effect produced by the simple expansion of very highly compressed, imperfect gas. A simple nozzle may be used, and a small cooling effect may be realized. This cooling has been determined, by experiment, to be about 45 deg. C., when the initial pressure is 200 atm. and temperature 0 deg. C. If the initial temperature is —60 deg. C. and pressure is 200 atm., the drop through a nozzle is increased to 73 deg. C. This cooling effect is therefore equal to $0.241 \times 45 = 10.8$ cal. per kg. for the first case or $0.241 \times 73 = 17.6$ cal. per kg. for the second case.

These figures are interesting, when compared with those for the heat which must be discharged during the separation of the air. This figure was shown to be 10.54 cal. per kg. air, and this is practically equal to the cooling effect possible with a plain nozzle working 200 atm. to 1 atm. and at 0 deg. C.

For the purpose of actual air separation, however, an auxiliary refrigeration machine is used, and by pre-cooling to —60 a margin of $17.6 - 10.54 = 7.16$ cal. per kg. may be had, to abstract heat entering the separation system from other causes, such as conduction through the insulation, or along the metal structure. This analysis is borne out by the practical operation of such machines, which require pre-cooling by a refrigeration machine to secure any useful effect. In this case the main current of separated gases can carry the excess of cooling—i.e., 7.16 cal.—up to the temperature at which the auxiliary system can pick it up, and so discharge the heat to the surroundings.

There is no way possible in nature to increase the cooling by the Joule-Thompson effect, for a given difference of pressure, and starting at a given temperature. Hence this feature is incapable of improvement, except by pre-cooling or by increasing the range of pressure. The pre-cooling appears to be an inexpensive way, and this system really amounts to a double, or binary system; in which the heat liberated by the separation of the air is picked up at, say, —60 deg. C. by a CO_2 refrigeration system, and is then rejected to the atmosphere or surroundings. This is not the usual explanation, but it is a sound presentation of the matter. There is a fallacy in the current idea that this process has a claim to efficiency. The explanation is not difficult.

It will also be found that the other system, which uses expansion engines, has a vital defect in common with the nozzle system and is little better in fact than the nozzle system with pre-cooling refrigerator. The expansion engine may remove 20 cal. or so per kg. of expanded air, and may be said to be from 20 to 25 per cent more efficient than the nozzle system, if the term efficiency is allowable, in a case where the effective work done is less than 10 per cent of the applied work of compression. It may appear that a loss of 90 per cent of the applied work would create some visible or evident result in connection with the apparatus. This is not true; the work of compression may be altogether lost without the appearance of any compensating heat or energy in the system. It is this point which requires clearing up, and it must be said that it is unfortunate that the point has been obscured by defective explanations so that some perfectly simple physical facts have become involved, making the true simplicity difficult to expose. It will be shown that by far the largest loss of power in all existing systems is caused by the simple transmission of heat contents from a high-pressure gas to a low-pressure gas without any apparent or useful effect other than the loss of pressure on the gas. It is not the act of throttling, but the improper heat transfer, which is the true cause of loss of power.

ELEMENTS OF LIQUEFACTION

To fix our ideas, we may take a simple gas, such as oxygen alone, and suppose this to be compressed to a considerable pressure. We may construct an elementary exchanger in the form of a simple U tube, Fig. 1. Suppose oxygen to be compressed into this tube, which may be kept cold at the U end, so that liquid oxygen will collect in the bend of the tube. An auxiliary refrigeration system may be used to keep the tube cold against inward leakage of external heat. Now suppose a throttle valve be placed in the bend of the tube so that the liquid formed in the high-pressure leg will be expanded, say, to 1 atm. pressure. The result would, of course, be that the liquid would become much colder and would at once evaporate, if it could get any heat. If the high-pressure-entering branch be in close contact with the low-pressure-exit tube, it is evident that the liquid may evaporate at low pressure in the second leg, while condensing fresh liquid at high pressure in the first leg. This is a simple form of the nozzle or Linde system, or perhaps it should be called the Hampson type. This very simple apparatus would
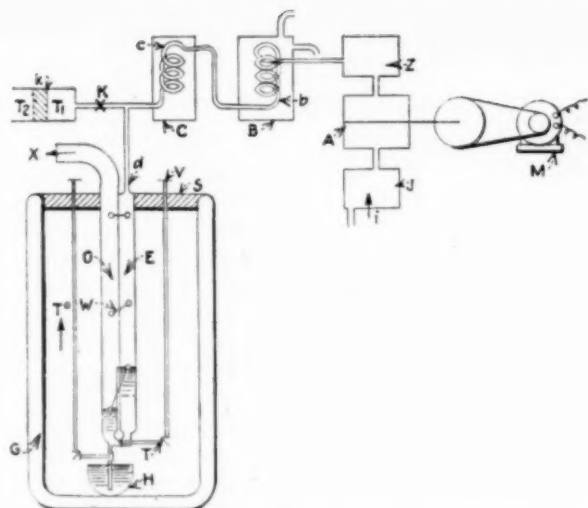
FIG. 1. LIQUEFACTION SYSTEM WITH THROTTLE. LINDE
OR HAMPSON TYPE

A Air compressor for 3,000 lb. pressure. *B* Water vessel con-
taining coil *b*. *C* Vessel with ice and salt freezing solution and
coil *c*. *d* Copper tube leading to leg of *U* tube of very thin copper.
O Other leg of *U* tube. *T-V* Throttle valve. *X* Escape passage
for air at low pressure. *G* An insulating chamber. *S* Cover for
insulating chamber. *Z* Chemical drier. *J* Chemical purifier. *M*
a motor. *k* Porous plug apparatus for demonstration only.

liquefy air or a simple gas if a pressure of 200 atm.
be used. The efficiency is absolutely zero if a simple
gas be expanded in this way, except that, in fact, the
liquid would accumulate at the bend of the tube and
a considerable amount of liquid might be removed as
liquid air, oxygen, or whatever the substance might be.
In all cases, however, the whole of the work of com-
pression will have been lost, because the gas will issue
without pressure, and hence cannot be made to do any
useful work—i.e., the gas has lost potential.

Now, suppose that the system is maintained cold by
an auxiliary refrigeration, Fig. 2, and that the pres-
sure is only slightly less in the exit tube than it is in
the entering tube. Then there would be a slightly lower
temperature in the low-pressure tube than in the high-
pressure one, and the liquid formed at high pressure
could be evaporated at slightly lower pressure in the
other leg. In fact, the re-evaporated substance could
return to atmospheric temperature at practically its
initial pressure. A portion of the issuing gas can evi-
dently be used to refrigerate the system against
external heat leakage and losses if desired. We are
neglecting this factor for the present, in favor of more
vital matters. The gas would have been liquefied, and
hence would have passed through a suitable state for
distillation (the still is not shown), but the larger por-
tion would issue from the apparatus at high pressure.

RECOVERY OF COMPRESSION WORK THE ESSENCE OF LOW COST

It is obvious that since the high compression of the
original gas is the main cost of the whole operation
(which, if lost, becomes prohibitive for large-scale oper-
ation), we have an obvious means for recovering the
primary compression work—simply to heat the escap-
ing gas at high pressure and expand it in a motor
cylinder. If a moderate drop in pressure may be main-
tained (and in fact such an apparatus may work with
less than 1 atm. drop in pressure), it is perfectly
feasible to heat escaping gas enough, not only to drive
the primary compressor, but even to do some extra use-
ful work. This is in essence the fundamental basis of

the Jefferies-Norton system—i.e., to preserve, or con-
serve, the potential of the compressed gas. This is the
primary improvement in the direction of lower cost,
simply to avoid throttling.

Now, the case is different for a mixed gas, such as
air, from that for a simple gas.

CONDENSATION OF A MIXED GAS

A mixed gas will not all condense at constant pres-
sure and temperature, and conversely it evaporates at
constant pressure with a rising temperature. If in
our air apparatus we have in some way caused the oxy-
gen and nitrogen to separate, we have the further diffi-
culty that air condenses at a much lower temperature
than the boiling point of oxygen at the same pressure.
That is, air condenses at 80 deg. C. abs., while oxygen
boils at 91 deg. C. abs., both being at 1 atm. pressure.
Hence, in our simple U tube we must increase the
pressure on the air tube until air will condense while
boiling oxygen in the other leg, and the air must be
compressed to about 2.8 atm. in order that this may
happen. Exactly similar relations hold for higher pres-
sures, and a ratio of 3 may be taken as the compression
required. It is evident, on the other hand, that the
nitrogen will easily be evaporated while condensing
air at equal pressure, since nitrogen boils at 77.35
deg. C. abs. and air condenses at about 80 deg. C. abs.,
both being at 1 atm. pressure. It is plain, therefore,
that the desirable feature of maintaining the escaping
gases at substantially the pressure of primary com-
pression will meet an obstacle in the fact that the air
cannot be condensed by free exchange of heat with
the condensed oxygen, and unless this obstacle can be
removed, the project of recovering the work of com-
pression will fail. Unless we can maintain sufficient
gas throughout the process at a sufficient pressure, we
cannot drive our primary compressor *WC* (see Fig. 3)
by heating and expanding the escaping gas in a motor,
and a very desirable economy will be lost. The device
of transferring the latent heat of condensation of the
condensing air to the evaporating oxygen will now be
described.

The distillation of a mixed liquid is a very complex
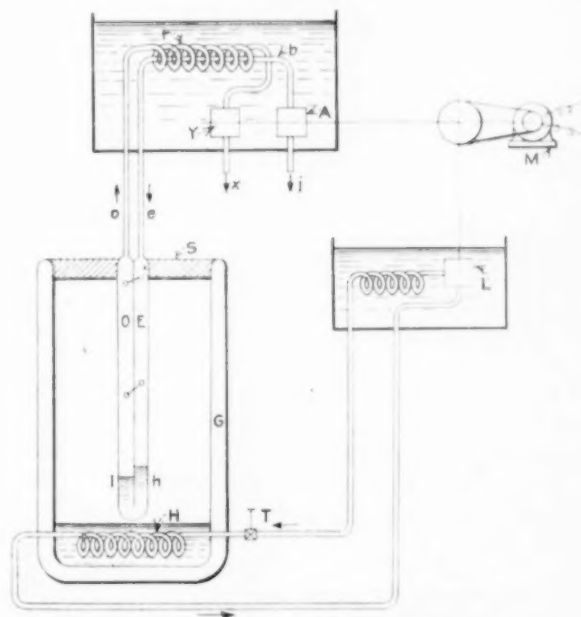operation to analyze in detail. A few facts stand out

FIG. 2. LIQUEFACTION SYSTEM WITH AUXILIARY
REFRIGERATION

clearly, and it will be found that these are the vitally effective points as respecting the economy of the system.

First. The liquid oxygen at the bottom of the still column is hotter than any other part of the column, hence no heat can flow by itself into the oxygen from any other part of the column itself. This fact is self-evident, but the consequences are so far reaching that the full treatment would require more space than we can give. It must be concluded that heat must be added to the oxygen from some outside source, if natural heat flow is to be depended upon. The use

FIG. 3. SKETCH OF JEFFERIES-NORTON SYSTEM IN FORM OF ENTROPY DIAGRAM

of a condensing coil which contains highly compressed air, to be condensed while evaporating the oxygen, evidently amounts to adding heat from an outside source, and this heat must afterward be removed from the still. (This is the plan usually followed.)

Second. The oxygen in any column must reach the bottom as a liquid. This follows since the still functions solely because the descending liquid always contains more of the less volatile substance (i.e., oxygen) than the ascending vapor, and it is the liquid reflux in the column which carries out the separation of oxygen, by "washing" it to the bottom.

Third. The oxygen must be evaporated in exchange for an equivalent amount of liquid air. This must be true, since no system which wastes the cooling effect of such a large amount of such a cold liquid can possibly be commercial or effective.

Fourth. The liquid toward the nitrogen (cold) end of any column will exchange latent heat with condensing air at the same pressure. This is evident, because pure nitrogen always boils at a lower temperature than that of the air mixture at the same pressure. Granted a sufficient quantity of liquid nitrogen, or high-nitrogen liquid, it is possible to exchange this for an equivalent amount of liquid air by free or natural heat flow at equal pressure.

Fifth. The column must be heated at the bottom and be cooled at the top. The logical proceeding is an unusual one, followed by the Jefferies-Norton system alone. It is this very vital step which advances the art of air separation into the region of fair efficiency and effectiveness. Since a cold spot must be cooled (nitrogen end) and a warmer spot must be heated (oxygen end), it is evident that a proper proceeding

would be to take heat from the nitrogen and reject this heat to the oxygen.

MECHANICAL TRANSFER OF LATENT HEAT

The very simple expedient of placing a coil in the oxygen space at bottom of still, in which compressed oxygen may be condensed, at a pressure very little above the still pressure, will evidently cause the oxygen in still to evaporate (as it must by third condition). The oxygen which has condensed in the coil at the bottom may then be throttled into another coil, at the top of the column, to a low enough temperature to condense nitrogen. If we work the still at 10 atm., we can condense nitrogen at 104 deg. C. abs., by boiling oxygen at 3.5 atm. somewhat below 104 deg. C. abs. In this way we evaporate the oxygen at the bottom of the still in almost perfect exchange for an equal mass of liquid oxygen which would be formed in the coil at bottom of the still. This "transfer" liquid, when throttled to 3.5 atm. and evaporated in the coil at the top of the still, will exchange for liquid nitrogen, which would be condensed out of the vapors at the top of the column. We may have 0.23 kg. oxygen to be evaporated in the upper transfer coil at 3.5 atm., latent heat 49.3 cal. per kg.; the latent heat of nitrogen being 37.5 cal. at 10 atm. Therefore, $0.23 \times (49.3 \div 37.5) = 0.3$ kg. of liquid nitrogen may be condensed at the head of the column in exchange for 0.23 kg. liquid oxygen which is evaporated at the bottom of the column by the action of the cold compressor and the heat "transfer system"—i.e., coils at top and bottom of the still. The liquid nitrogen, which would be condensed at the head of the column, would run downward through the usual form of trays, and would cause the condensation of the air in these trays in exchange for higher and higher oxygen liquids which would pass on to the bottom.

REMOVAL OF LOSSES AT HIGH TEMPERATURE

If we could build an adiabatic compressor, the transfer of heat could be made without introducing any heat into the still. Taking the operation as a whole, exactly as many calories would be withdrawn from the nitrogen space into the substance of the transfer fluid as would be given up by the transfer fluid to the liquid oxygen which must be evaporated at the bottom of the column. The heat would simply be taken away from the top of the column and would be restored in equal amount to the bottom of the column, but at a higher temperature. The transfer circuit is thus a simple refrigeration system, taking heat from a colder spot and rejecting it to a warmer one, with the necessary result that work must be used up to drive the compressor.

Now, no compressor is perfectly adiabatic. However, it is fortunate that the effect of imperfection is to superheat the discharge of the cold compressor, which, being at a much higher temperature than the still itself, may be cooled by an expansion engine or other refrigeration means. The temperature being 162 deg. for the adiabatic compression of oxygen at 3.5 atm., we may expect 181 deg. abs. for the actual compressor; so that this extra heat has to be removed between —92 deg. C. and —113 deg. C., in order to compensate for the mechanical imperfection of our cold compressor. Now, the amount of heat which an expansion engine may remove per kg. of fluid varies directly as the temperature of the inlet, or the exhaust; and by raising the temperature to 162 deg. as com-

pared to, say, 100 deg. in the older systems, we have increased the cooling effect of the expanders by 62 deg.; or, in other words, the cooling effect per kg. expanded has been increased to 1.6 times that for an engine working at 100 deg. C. abs. exhaust temperature. The superheat may be absorbed into the inlet gas of the expansion engine with a great gain.

The novelty of introducing a compressor to work at these very low temperatures is thus seen to be justified on practical grounds.

The heat transfer system is the direct, natural way to abstract heat from the air to be condensed, and to reject this heat into the oxygen and nitrogen, which have been separated in the still.

THE NEW SYSTEM

The theory of this subject forms a very interesting problem in thermodynamics. It may appear that the positive statements made may not be susceptible of proof, but there are two satisfactory methods available. The first of these is by actual heat content calculations by means of an entropy diagram. Such a diagram has been made, and has been found fairly accurate, so that heat contents may be compared over the whole range of temperatures and pressures. This is a very intricate matter.

The more satisfactory proof is by means of a simple sketch diagram. The idea is to consider a plain tube (*E-O*, Fig. 3), to be bent to the approximate form of
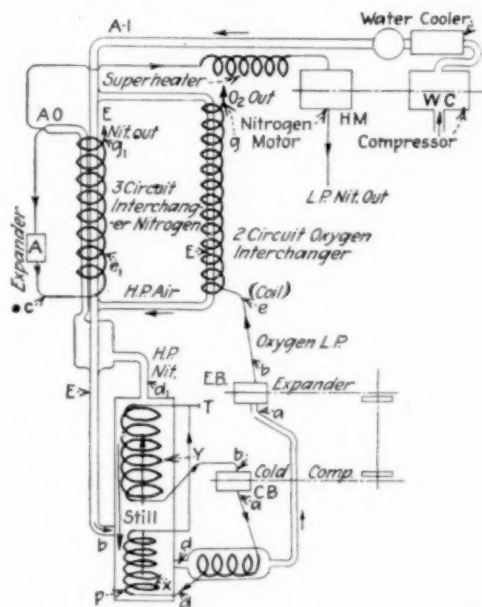
FIG. 4. JEFFERIES-NORTON LIQUEFACTION SYSTEM

the entropy diagram. The passage of a portion of gas, say the oxygen, through the tube will be represented in heat contents and temperature, if it is remembered that areas under the representative line show heat contents.

By the device of superposed coils, like *e*, which are wound around the plain tube, we may perform various cooling and heating operations on the substance in the plain tube. It will be noticed that the plain tube is in reality the U tube of Fig. 1, but that the throttle has been replaced by a pump. This pump is only ideal, and its function is actually performed by heat in the actual apparatus.

This method is an extension of the Carnot theorem,

but using adiabatic-constant pressure lines instead of the adiabatic-isothermal cycle of Carnot. By either method a conclusive proof may be made, but space does not permit the full analysis, which may be found somewhat tedious. We will, therefore, pass on to a description of a working system.

We refer first to Fig. 4 for a schematic apparatus which is lettered to correspond to Fig. 3.

Fig. 3 is a sketch entropy diagram, made closely to scale. Fortunately our proof will not involve any of the peculiar properties of entropy. The working of the apparatus may be followed easily from Fig. 4, which has been reduced to the simplest terms. There are three novel features concealed in this apparent simplicity.

First. The heat exchange is, so far as possible, between gases at as near equal pressure as the friction of the apparatus will permit. That is, the two main currents in the nitrogen-air exchanger E_1 are at equal pressure. The oxygen-air interchanger E, however, is cooled by a low-pressure stream, and this is according to the strict theory of the laws of compression of gases in such a system.

Second. The oxygen at the bottom of the still is to be boiled (evaporated) by the introduction of heat at that point, and this heat will be abstracted from the column at the colder top, where nitrogen is to be condensed.

Third. All the expanders work on gas which has passed through the still.

These gases are in both cases warmed up before expansion, by heat which is abstracted from the high-pressure gas in the system. This feature is particularly to be noticed in the case of the oxygen compressor *CB* and the oxygen expander *EB*. All super heating and loss of the oxygen compressor is to be rejected to the *inlet* of the oxygen expander (*a* to *d*, Fig. 4). The cold exhaust of this cylinder is applied to the compressed air in the exchanger *E*, and this exhaust and the escaping nitrogen from the top of the column are cold enough to condense a considerable amount of liquid out of the entering air. This liquid flows into the still, where it is available to neutralize the external heat leakage and other imperfections of the apparatus. This action is aided by the nitrogen expander *A*, which may, in fact, consist of a pair of engines which are powerful enough to produce a considerable amount of liquid air, to protect the system against external heat leakage. The expanders *A* have no other duty than to overcome imperfections of insulation. The whole of the theoretical cooling required by the separation of the air (compression from partial pressure to total pressure of oxygen and nitrogen) would be performed by the pair of engines, compressor *CB* and expander *EB*. In the 10 atm. system, the oxygen would actually be expanded in *EB* to 1 atm., while it would enter at 2 atm. partial pressure, and this overexpansion provides a margin of cooling, since the compressor need only work through a pressure range from 3½ atm. to 10 atm., while the expander *EB* will work from 10 atm. to 1 atm. The device of cooling the discharge of the compressor *CB* by the high-pressure oxygen vapor from the still will again be noted, as it is most essential that the system be stabilized in this way.

The transfer circuit may easily be followed, remembering that oxygen must be boiled at the bottom of the column and nitrogen must be condensed at the head of the column.

The throttle *T* differs from the usual throttle, since the coils at bottom are carried up, so the liquid oxygen will be cooled from its boiling point, at 10 atm., to the temperature of liquid air at the entrance of the still; and hence the release of pressure by the throttle *T* will result in very little fall in temperature and very little evaporation during the throttling. In fact, there would be no loss at this point. This conception is a little difficult to grasp. If the comparison is made with an ordinary water tap, where water, far below its boiling point, is released from pressure without any perceptible drop in temperature, it will be seen that if the oxygen is already cooled to, say, 104 deg. it will evaporate very little in expanding to 3.5 atm., where it boils at 104 deg., while condensing nitrogen in the other side of the tube. This is not throttling in the usual sense. Practically there are certain imperfections of apparatus, but fortunately they may be made to closely approach the vanishing point.

The critical part of this whole system is the possibility of retaining enough nitrogen at high pressure to be superheated to, say, 1,000 deg. F., before expansion in the heat motor *HM* in order to drive the compressor *WC*. If 50 per cent of the original air can be returned to *HM* as superheated nitrogen, the heat will drive the system. The cost of fuel for such a system is very small, since a thermal efficiency of 60 per cent or more is easily reached.

It will be noted that the only useful mechanical effect produced by this system is the separation work—i.e., 10.54 cal. per kg. of air—and this is met by the expansion of the oxygen. The removal of heat leakage has required the expansion of, say, 0.5 — 0.23 = 0.27 kg. of nitrogen. There is left 0.5 kg. nitrogen to be heated, enough to make good these expenditures of power.

CONCLUSION

The investigation on which these notes are founded has consumed about seven years of research into the problems involved in gas separation. A great mass of information has been accumulated as to the properties of the greatest variety of substances, and the practical side of the matter has been attacked in translating the experimental data into useful form.

It is not to be expected that all points of interest or doubt can be covered in the scope of such a summary as we have been able to make here. There is one fact which stands out clearly beyond any possible doubt: The whole basis of the present oxygen and nitrogen systems is extravagant and uneconomical.

The future of oxygen developments depends on the courage of the industry, in first daring to depart from precedent, and then on active prosecution of both the production and consumption processes. The process of oxygen production is without value unless the demand for oxygen is certain and insistent. We have endeavored to present the claims as to the cost of production fairly, with the view that the application may be as seriously considered. There is no doubt that oxygen and nitrogen will be produced at a price allowable for the fullest development of chemical and metallurgical processes through a process founded on sound thermodynamic principles.

The fact that no ideal process can be carried into practice with perfect effect does not alter the fact that no process which is defective in its basis can be made to exceed its fundamental efficiency. The existing systems are fundamentally defective in two respects, neither being in any way a necessity in the air separation process.

First. The expansion of all the air at very low temperatures, which results in a total loss of primary compressor work, without any compensating benefit.

Second. The introduction of external heat into the still (by the condensation of air at high pressure). The separation of the air requires the compression of the oxygen and nitrogen from their partial pressures at entry to the still to the total pressure on pure gases leaving the still. This means the expenditure of work to a moderate degree, if performed at the temperature of the still. The usual systems violate the natural demands, by compressing air at atmospheric temperature, to perform indirectly the work of separation at a very low temperature, and add to this defective process the further false step of introducing heat into the bottom of the column, which may only be removed by the evaporation of liquid air, as such, without separation.

These defects may be removed by modifications of the cycles; the mechanical processes and the structure of the apparatus may undergo little apparent change.

To secure favorable results:

First. Transfer the heat contents of all high-pressure gases to return current of high-pressure gas. All heat contents of low-pressure gas to low-pressure gas return. Absorb all heat leakage and loss into high-pressure gas at as high temperature as possible.

Second. Carry out all heat leakage and the heat liberated by separation of gas in the smallest possible current of low pressure gas at the highest possible temperature.

Third. Reduce the temperature difference between any two streams of gas, particularly at the cold end of the apparatus, to the lowest possible amount.

Fourth. Exchange the latent heat of condensation of entering fluids, as exactly as possible, for the latent heat of evaporation of escaping fluids, and avoid the production of liquid air by the cooling effect of nozzles or expansion engine.

Fifth. If any compression work must be done to separate any mixture, do this work at the temperature of separation, rejecting all heat to high-pressure return circuit, with subsequent high-temperature expansion to compensate the system.

By careful attention to these principles in detail, there is no doubt that the costs of oxygen (and nitrogen) may be so reduced that all the applications considered in the first part of this article are feasible. This may be accomplished, without introducing any new physical or mechanical actions, by simply following closely the principles of sound thermodynamics as applied to the relation between heat and work, and to the effect of the transfer of heat contents from a high-pressure gas to a low-pressure gas.

The work represented by the transfer of heat from one temperature to another depends not only on the amount of heat transferred but also on the temperature at which the transfer is to be accomplished. The free transfer by conduction of heat contents from a high-pressure substance to the same substance at low pressure results always in the total loss of potential— i.e., in the loss of the primary work of compression of the high-pressure gas.

No separation process which violates these principles can reach any degree of efficiency which deserves the name.

Production of Sodium and Sodium Compounds in the U. S. in 1919

THE production of sodium and sodium compounds in the United States in 1919 amounted to 9,190,000 tons, valued at $114,700,000, according to preliminary estimates made by R. C. Wells, of the United States Geological Survey, Department of the Interior. These figures show a decrease of 10 per cent in quantity and 20 per cent in value as compared with those for 1918. The figures showing the production of the various compounds in 1919 together with the corresponding final figures for 1918 are given in the following table.

SODIUM AND SODIUM COMPOUNDS PRODUCED IN THE
UNITED STATES IN 1918 AND 1919

| | 1918 | | 1919 | |
	Quantity (Short Tons)	Value	Quantity (Short Tons)	Value
Sodium (metallic)	264	$153,437	(a)	(a)
Sodium acetate	622	460,783 (c)	2,540	$129,400
Sodium benzoate	203	886,058	184	575,000
Sodium bicarbonate	118,535	3,293,153	137,005	3,526,204
Sodium bichromate	28,334	9,868,118 (c)	26,700	6,407,000
Sodium bisulphite and sodium sulphite	16,362	478,482 (c)	2,000	693,000
Sodium bromide	574	438,730	924	493,319
Sodium carbonate:				
Soda ash	1,390,628	35,635,520	981,354	29,824,245
Monohydrate and sesquicarbonate	22,678	482,958	30,796	710,748
Sal soda	82,465	2,020,271 (c)	74,200	22,082,000
Sodium chlorate and sodium perborate	2,413	1,004,250	1,217	64,959
Sodium chloride (b):				
Salt in brine	2,830,600	1,245,265	2,809,000	
Rock salt	1,683,941	5,684,661	1,637,300	27,296,000
Evaporated salt	2,724,203	20,010,435	2,618,200	
Sodium citrate, tartrate, and bitartrate	(a)	(a)	32	56,553
Sodium cyanide and sodium peroxide	9,077	5,361,000	9,196	4,558,126
Sodium iodide	(a)	(a)	12	85,451
Sodium ferrocyanide	4,525	2,690,110	3,437	1,346,285
Sodium fluoride, acid sodium fluoride, and sodium fluosilicate (silicofluoride)	1,879	387,234 (c)	1,680	343,000
Sodium hydroxide (caustic soda)	513,363	31,854,470	347,440	20,368,308
Sodium nitrate (refined)			6,512	651,047
Sodium nitrite	1,701	609,779	431	151,621
Sodium phosphate (including all sodium phosphates)	15,630	1,427,947 (c)	17,370	1,935,000
Sodium silicate	317,161	5,870,973 (c)	174,000	3,390,000
Sodium sulphate:				
Salt cake	141,054	2,844,897 (c)	125,470	2,173,800
Glauber's salt	50,715	1,041,076 (c)	45,000	914,000
Niter cake	143,155	595,660 (c)	61,090	169,600
Sodium sulphide	45,490	2,293,304 (c)	19,740	1,249,000
Sodium tetraborate (borax)	26,673	3,903,565	28,518	4,351,891
Sodium thiosulphate (hyposulphite)	26,868	1,051,623 (c)	19,400	897,000
Miscellaneous sodium compounds	390	1,188,792	560	253,513
	10,199,493	$142,788,545	9,190,000	$114,700,000

(a) Included in miscellaneous compounds.
(b) Insley, Herbert, "Salt, Bromine and Calcium Chloride," U. S. Geol. Survey, Mineral Resources, 1919, p. 2.
(c) Figures for 1919 are partly estimated.

The production of sodium compounds derived from natural sources, exclusive of common salt, amounted to 31,890 tons, valued at $841,903, in 1919, as compared with 24,053 tons, valued at $992,788, in 1918.

IMPORTS AND EXPORTS

The imports of sodium salts in 1919 amounted to 522,000 tons, valued at $20,704,000, as compared with 2,111,000 tons, valued at $90,939,000, in 1918. This great decrease in 1919 was caused almost entirely by a decrease in the imports of sodium nitrate, which is the sodium salt imported in largest quantity, the imports of all other sodium compounds having actually increased in 1919 over those in 1918. The imports of sodium cyanide, sodium ferrocyanide and sodium sulphide were notably greater in 1919 than in 1918.

The exports of sodium salts in 1919 decreased about 17 per cent as compared with those in 1918. As the accompanying table shows, this decrease was due largely to smaller exports of soda ash, as the exports of caustic soda and miscellaneous sodium salts show an increase.

DOMESTIC SODIUM SALTS EXPORTED IN 1918 AND 1919, BY
CLASSES

| | 1918 | | 1919 | |
	Quantity (Short Tons)	Value	Quantity (Short Tons)	Value
Sodium carbonate:				
Soda ash	119,217	$7,805,550	50,481	$2,656,608
Sal soda	6,358	213,865	5,563	178,285
Sodium chloride (common salt)	136,783	1,677,577	119,415	1,396,625
Sodium hydroxide (caustic soda)	48,689	5,602,813	82,116	6,748,762
Sodium silicate	14,125	404,796	12,150	338,818
All other sodium salts		6,587,134		7,226,322
Total		$22,291,735		$18,545,420

EFFECT OF THE WAR ON THE USE OF SODIUM COMPOUNDS

The use of sodium compounds in place of potassium compounds, which was begun of necessity during the war, was largely continued in 1919. The war left the United States with a greatly augmented capacity for producing certain chemicals, especially those used in making explosives and dyestuffs. The manufacture of these materials consumes large quantities of sodium nitrate, all of which is imported, and the work of building up an independent nitrogen industry in the United States has been and still is difficult. The large Government plants projected or built during the war were intended to produce fixed nitrogen compounds in the form of lime-nitrogen, ammonia, and ammonium nitrate. No sodium nitrate produced by the fixation of atmospheric nitrogen has yet been marketed in the United States, but as ammonia is a necessity in the Solvay process of making soda and is used also in making sodium cyanide, any developments in the ammonia industry will eventually affect to some extent the soda industry.

USES OF SODIUM COMPOUNDS

Sodium compounds are valuable either for their basic part or for their acid part. The price of the compounds that are used for their basic part is very low, as the sodium acts only as a carrier of the other elements in the compounds; the price of the compounds that are used for their acid part differs according to the value of that part. Although the price of soda ash is low, the value of the total soda ash produced annually in the United States amounts to millions of dollars and nearly equals that of the total annual production of lime, which is the next cheapest alkaline substance. Soda ash has many and various applications. It is used in making glass, soap, paper, chemicals, drugs, paints, leather, enamel ware, and cleansing agents, in refining oils, and in metallurgy. The uses of the other compounds of sodium vary according to the elements of which they are composed. The uses of the individual salts of sodium, together with a list of producers of each salt, are given more fully in the chapter on sodium compounds in "Mineral Resources of the United States," published annually by the U. S. Geological Survey.

PRICES

The prices of most sodium compounds were considerably lower in 1919 than in 1918. At the beginning of 1919 the prices of nearly all compounds were the lowest for at least three years, but later in the year they improved somewhat and the improvement has continued practically up to the present time.

Legal Notes

BY WELLINGTON GUSTIN

Compensation for Death Hastened by Aggravation of Disease Due to Explosion

As a result of an explosion of a still in 1917 in the plant of the National Aniline & Chemical Co. an employee was apparently but slightly injured in the jaw. While the bruise quickly disappeared, a pain in the jaw continued to increase. Upon an examination a malignant cancer was found. The affected parts were shortly removed by an operation, but the disease recurred within a few months and the employee died within six months after his injury.

The State Compensation Board awarded compensation to the employee's widow on the ground that the accident aggravated the cancerous condition and caused death at an earlier period than would otherwise have occurred, the medical testimony indicating that "a local injury might cause an otherwise slow-growing cancer to light up and develop with great rapidity." The award of the Compensation Board was upheld by the Supreme Court of Pennsylvania.

Obligations Upon Agreement to Surrender Contract of Exclusive Right to Handle Product

The Appellate Division of the Supreme Court of New York has affirmed judgment in favor of James A. Cleveland and another in their action brought against Mason J. Clark for balance due on contract. It appears that on July 3, 1917, a contract was made between the parties whereby Mason should deliver f.o.b. the cars at Arnot, Pa., a bituminous product of coal, which he was producing and selling at a certain price, and Cleveland should sell the product and remit therefor, the contract to be in force to May 16, 1922. In July, 1918, the parties entered into another contract, providing for the cancellation of the former contract and in consideration of the surrender of this contract by Cleveland, Mason was to pay $1,000 down, and balance a later date. Mason refused to pay the balance due after the date fixed. It seems there arose the question of whose duty it was to first perform.

The court said whether the mutual terms of a contract are dependent, so that either party, in order to recover upon it, must show a tender of performance on his part, depends always upon the intent of the parties as gathered from the contract itself.

Where the defendant in a mutual contract is to pay plaintiff certain moneys on a day stated, and neglects to pay them, the plaintiff must tender or offer to tender performance on his part as a condition precedent to his right of recovery for the defendant's default. If there is no express provision in the contract, it will not be assumed that the one party is to pay and give credit to the other for the performance in the future, but upon making the payment he has the right to receive performance by the other party as a condition thereof. Where a contract requires contemporaneous performance, neither party can sue at law until he has, by performance or tender on his own part, put the other in default.

Therefore, the court said, if the subject of the contract was a sale of property, clearly there could be no recovery of the purchase price after the law day without an offer to deliver, as the delivery is the real consideration for the payment.

When the contract was executed and the $1,000 paid, Mason's liability and Cleveland's obligation under the original contract were at an end, said the court. It would be an idle ceremony for Cleveland to hand over to Mason the duplicate original contract which he held; there was no way prescribed in which their rights were to be surrendered. The contract under seal surrendered the original contract, and the rights of Mason thereunder.

In any event the payment of the $2,000 would effectually destroy the original contract, and no affirmative action on the part of Cleveland could be had after such payment, and he was not, therefore, required to do any act, as delivery of his duplicate contract, as a condition of maintaining his suit. Judgment for Cleveland was affirmed with costs.

Loss in Shipment of Menthol Acetate Depends on Duty to Unload Under Contract

A new trial has been ordered in the case of the Barton Lighterage Co. against La Brecque Co., Inc., by the New York Supreme Court in Appellate Term. The facts show that the former agreed to lighter 620 drums of menthol acetate from Greenpoint to the New Jersey Zinc Works on the Hackensack River; that loading of the drums began on March 14, but no evidence is given as to how long it was required to reach the zinc works.

The next evidence is that plaintiff's foreman saw the lighter tied to the bulkhead of the New Jersey Zinc Works on April 8; he did not know when it reached there. When he arrived the lighter was listing about 45 deg., and about five minutes after his arrival the lighter suddenly "groaned," turned over and spilled a number of the drums into the water. All but eight were subsequently recovered. Upon these facts the jury found for plaintiff for the full amount of its contract.

The court on appeal said there was no evidence as to whether the contract for lighterage included the loading and unloading of the drums in addition to their transportation. The contract is silent on that point unless the words "to lighter" include, in addition to transportation, the loading and unloading of the menthol acetate to be transported. If the contract included loading and unloading, then the Barton company did not show performance, for the drums were never unloaded completely at the New Jersey bulkhead, and no evidence accounts for the failure to unload, or for the listing of the boat, said the court. But, even if the unloading was no part of the Barton company's agreement and only a mere voluntary act on its part, still there was no complete performance of the contract proved, for it was the duty of the Barton company at least to transport the merchandise in question to the bulkhead in New Jersey in such a way as to give La Brecque company a reasonable opportunity, after the notice of arrival, to unload it.

No evidence was introduced to show these facts required, and for lack of sufficient evidence upon which to base a finding that the plaintiff had completely performed its contract the judgment in its favor was reversed and new trial ordered.

Production of Motor Gasoline From Heavy Oil Hydrocarbons

A Study of the Possible Specific Reactions Taking Place in Cracking Phenomena—Composition of Petroleum—Action of Catalysts Upon Heating—Deposition of Coke—Composition and Refining of Pyrolytic Distillates

By FRED W. PADGETT

PETROLEUM consists essentially of a mixture of hydrocarbons which are in the main totally miscible with one another. Organic nitrogen and sulphur compounds are also present in varying amounts, and occasionally oxygen compounds, as well as water and inorganic material in dispersed form. When this complex of naturally occurring hydrocarbons is subjected to dry distillation at atmospheric pressure, the hydrocarbons of lowest boiling point are vaporized proportionally to their partial vapor pressures and pass into the condenser followed by those of higher boiling point as the temperature rises. Varying degrees of fractionation will obtain, depending upon the design of still and method of operation. From the point where gases first appear at the condenser outlet until the temperature in the still reaches approximately 625 deg. F., the products secured are in the main natural—that is, they exist in the crude oil as such. Above this temperature, however, especially if the distillation is carried out slowly, what is known as "cracking" takes place and a distillate is secured which upon re-distillation

TABLE I. GASES FROM CRACKING DISTILLATIONS UNDER 100 LB. PRESSURE

From Jennings Crude

	1	2	3
	Deg. C.	Deg. C.	Deg. C.
Temperature in still	340	415	422
	Per Cent	Per Cent	Per Cent
CO₂	1.2	0.5	0.0
CO	1.2	0.5	1.3
Illuminants	15.4	15.3	13.0
Hydrogen	0.9	4.0	4.4
Saturated hydrocarbons	81.5	79.7	81.3

From Paraffine

	Deg. C.	Deg. C.	Deg.C.
Temperature in still	417	432	437
	Per Cent	Per Cent	Per Cent
CO₂	0.0	0.0	0.0
CO	0.0	0.0	0.0
Illuminants	25.4	37.0	33.5
Hydrogen	0.3	0.9	3.0
Saturated hydrocarbons	74.3	62.1	63.5

will yield more gasoline and kerosene, the quality, however, in most cases, not being comparable with that of the natural products.

If, instead of carrying out the distillation above the 625-deg. point at atmospheric pressure in an ordinary still, one of special design is used and the operation is conducted at a pressure varying from 50 to 150 lb. per square inch, profound decomposition or "cracking" occurs, and a yield of gasoline of 20 per cent or more, based on the original charge of residue or heavy distillate, may be obtained upon fractionating the pressure distillate secured. The residue remaining and the pressure distillate which has thus been freed from gasoline may again be subjected to the process and a further yield of gasoline secured, this being less than in the first case, and decreasing upon subsequent treatment.

The effect of pressure upon the yield of gasoline and the refining loss of sulphuric acid during pressure distillation is illustrated graphically in Fig. 1.[1] The volumes of gas evolved at various pressures during the course of the distillation is shown in Fig. 2,[2] while the variation in temperature during distillation and at various pressures is shown in Fig. 3.[3] The composition of the gas evolved during various stages of pressure distillation is shown in Table I.[4] The oil used in the
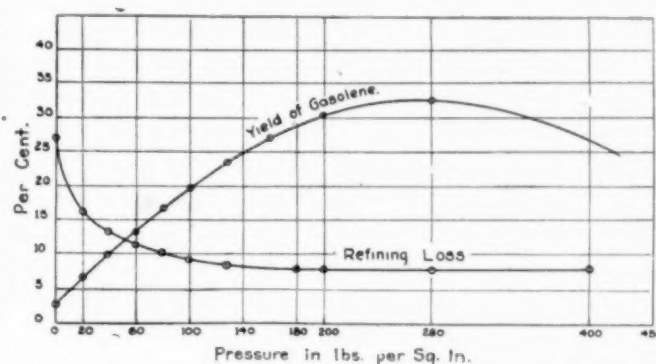
FIG. 1. EFFECT OF PRESSURE ON YIELDS AND LOSSES

above experiments was Oklahoma residual oil, and the apparatus a small experimental still of the autoclave type.

THE COMPOSITION OF PETROLEUM

Considerable knowledge has been gained concerning the composition of the lower fractions of petroleum due to the researches of Mabery and others. The presence of paraffines, naphthenes (cyclopentane, cyclohexane and their homologues), aromatics and olefines has been definitely established, while the evidence points to the presence also of cyclo-olefines, diolefines and possibly acetylenes.[5] Concerning the lubricating fractions of petroleum, there is some evidence pointing to the presence of olefines of high molecular weight which are but slightly acted upon by concentrated sulphuric acid,[6] also diolefines,[6] polynaphthenes,[7] and possibly compounds of the hydrogenated naphthalene[8] and anthracene[8] type. Pressed lubricating oil fractions show, by ultimate analysis, that the average general formula of the hydrocarbons is either C_nH_{2n} or C_nH_{2n-m}.

[1]Brooks, Bacon, Padgett and Humphrey, J. Ind. Eng. Chem., vol. 7 (1915), p. 180.
[2]Brooks, J. Frank. Inst., vol. 180 (1915), p. 653.
[3]Ibid.
[4]Brooks, Bacon, Padgett and Humphrey, J. Ind. Eng. Chem., vol. 7 (1915), p. 180.
[5]The latter three may be formed during the distillation of the crude oil.
[6]Brooks and Humphrey, J. Am. Chem. Soc., vol. 40 (1918), p. 822.
[7]See Gurwitsch's "Wissenschaftliche Grundlagen der Erdölbearbeitung," p. 19.
[8]Ibid., p. 20.

The pyrolytic researches on individual members of the hydrocarbon series have been mainly carried out on the lower constituents and the data are often conflicting, due to differing rate factors and to inaccuracies in temperature measurements. As a general principle it is known that the relative stability of the hydrocarbons to heat decreases as follows: Aromatics, naphthenes, paraffines, unsaturated hydrocarbons. This general principle, however, must be modified in certain cases, as the following discussion will show:

Where paraffines are present in the residual oils the following will represent a reaction undoubtedly taking place to a considerable extent.[']

$$R-CH_2-CH_2-CH_2-R \rightarrow R-CH=CH-CH_3 + RH \quad (1)$$
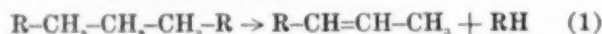
Gurwitsch[10] believes that the effect of pressure, among other things, is to cause the hydrocarbon chain of the heavier molecule to split nearer the center with resulting decrease in gas formation: namely, *symmetrical scission*. Other reactions, which may take place when hydrocarbons are "cracked," must be taken
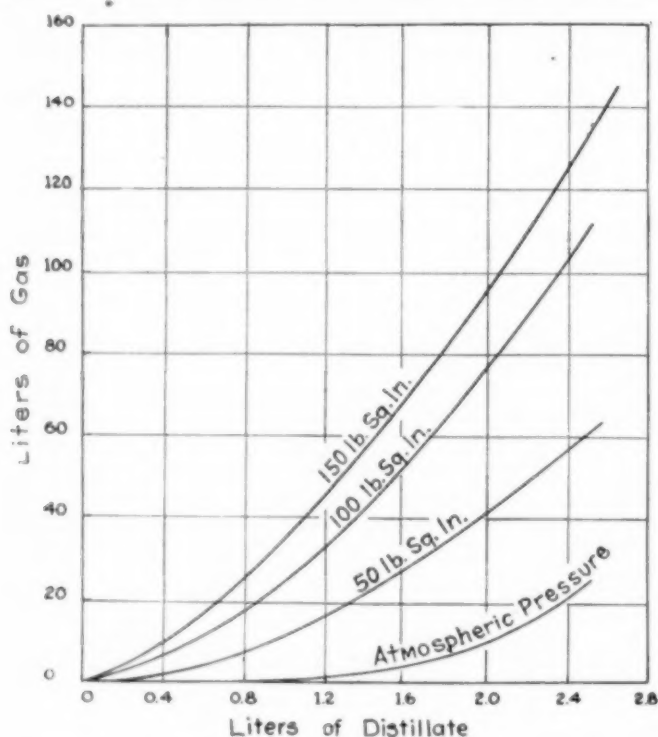
FIG. 2. VOLUMES OF GAS AT VARIOUS PRESSURES

into consideration when it is known that carbon is one of the products always encountered during "cracking."

$$R-CH_3 \rightarrow RH + C + H_2$$

or $R-CH_2-CH_2-CH_3 \rightarrow RH + CH_2=CH_2 + C + H_2 \quad (2a)$

$$R-CH_2-CH_2-R \rightarrow RCH_3 + C + RH \quad (2b)[11]$$
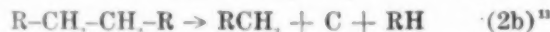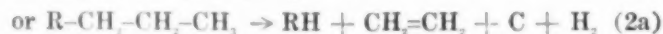
Reaction (2b) is characteristic of "cracking" under pressure.

Local superheating of the oil in contact with heating surface seems to influence the amount of coke formed as well as the character of the hydrocarbons; the asphaltic hydrocarbons, for example, being unstable toward heat and depositing carbon at comparatively low

temperatures. Iron also catalyzes the reaction in which paraffine hydrocarbons are broken down into carbon and hydrogen. (See *infra.*)

The paraffine wax of commerce is not readily acted on by anhydrous aluminum chloride, although the same initial substance upon pressure distillation will yield 20 per cent or more hydrocarbons in the gasoline range.[12]
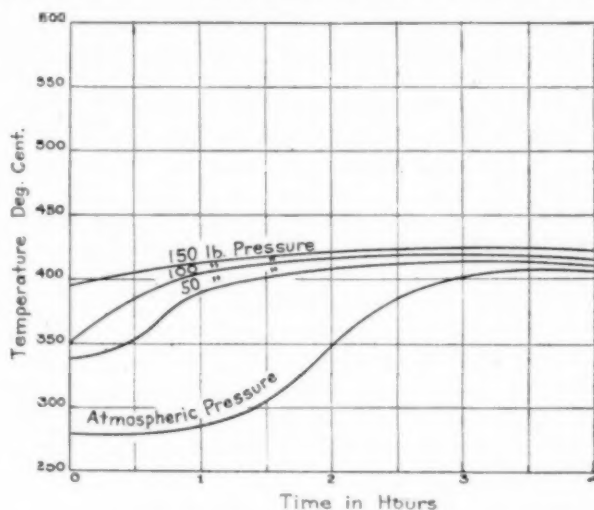
FIG. 3. VARIATION OF TEMPERATURE AND PRESSURE

Since the residual oils from petroleum may contain not inconsiderable quantities of olefines of high molecular weight, aromatics with long side chains, naphthenes with side chains, polynaphthenes, and even diolefines, it is interesting to speculate how these compounds may be modified by the action of heat, pressure and catalytic agents. Olefines, by the action of heat and pressure, tend to polymerize. It may be that olefines found in the residual oils first polymerize to give closed chain compounds with side chains which are then "cracked" to paraffine hydrocarbons and cyclo-olefines which in turn polymerize to give compounds of higher molecular weight and remain in the still. The following reaction is also one very probably for the olefines, the fact that some petroleums give but little gas during pressure distillation lending support to the hypothesis:

$$R-CH=CH_2 \rightarrow RCH_3 + C \quad (3)$$

Olefines may also be modified according to the following scheme,[13] diolefines evidently being present in cracked distillates:

$$R-CH_2-CH_2-CH=CH-R \rightarrow RCH=CH-CH=CH_2 + RH \quad (4)$$
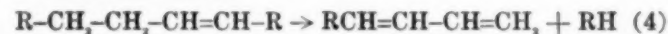
This is a reaction which is characteristic of high temperatures.

The naphthenes are known to be more stable toward heat than the paraffines, but with sufficiently severe conditions may be decomposed into diolefines, olefines, cyclo-olefines, benzol, and even paraffines.[14] Hydrocarbons of high molecular weight such as the polynaphthenes, hydrogenated naphthalene and anthracene should be much more unstable than the naphthenes we are familiar with, namely, cyclopentane and cyclohexane.

Anhydrous aluminum chloride readily polymerizes olefines,[15] so that when olefines are present in residual oils, the first action may be the formation of closed chain hydrocarbons with side chains attached which

[9]*Liebig's Ann.*, vol. 165, p. 1. This reaction was first observed by James Young.
[10]Gurwitsch's "Wissenschaftliche Grundlagen der Erdölbearbeitung," p. 145.
[11]In Bulletin No. 14 of the Kansas City Testing Laboratory, p. 95, specific reactions of this type are given.

[12]Brooks and Humphrey, *J. Ind. Eng. Chem.*, February, 1916.
[13]Dunstan and Thole, *J. Inst. Pet. Tech.*, vol. 2 (1916), p. 36
[14]*Ibid.*
[15]Heusler, *Z. Angew. Chem.*, vol. 9, p. 587. It is known that anhydrous aluminum chloride primarily forms double compounds with the olefines.

are then "cracked" to form paraffine hydrocarbons and cyclo-olefines, with the attendant polymerization of the latter. At this point should be mentioned the work of Pictet and Serczynska,[16] who advance the theory that the residual petroleum oils contain naphthenes with side chains which are acted on by the catalyst to form paraffines and cyclo-olefines, the latter polymerizing immediately by the action of the catalyst and remaining in the still:

$$C_5H_9-CH_2-R \rightarrow C_5H_8 + RCH_3 \qquad (5)$$

Brooks[17] believes that the higher fractions of petroleum contain aromatics with long side chains, basing his assumption mainly on the fact that upon pressure distillation of the paraffine wax of commerce at 100 lb. pressure no benzols are formed, while upon pressure distillation of various residual oils under the same conditions benzol is one of the products found in the distillate. Phenyl paraffine was synthesized by the Friedel and Crafts reaction and the final product was freed from benzol by steam distillation. Either pressure distillation of this synthetic product or treatment with anhydrous aluminum chloride gave a distillate containing benzol. In order to secure a saturated product from a compound of this type it would be necessary that coke be formed along with very little gas, a phenomenon which actually occurs when residual oils are treated with aluminum chloride:

$$C_6H_5-CH_2R \rightarrow C_6H_6 + C + RH \qquad (6)$$

Summing up the effects of heat alone on petroleum hydrocarbon mixtures of the gas oil type, Dunstan and Thole[18] state that at the lower temperatures where "cracking" occurs the products are a mixture of olefines and paraffines; at higher temperatures, near 700 deg. C., a mixture of olefines, diolefines and aromatics prevails, while at still higher temperatures tar and permanent gases containing much methane are produced. From the thermochemical point of view, the main reactions encountered during "cracking" are endothermal, reaction (1) being of this type. In testing the validity of theoretical possibilities the fact that the concentration of the reacting substances has its effect upon the equilibrium, and the law of Le Chatelier, are useful. The latter reads that when one or more of the factors determining an equilibrium is altered, the equilibrium is displaced in such a way as to tend to neutralize the effect of the change. As an example, consider equation (1), which is endothermal. The reaction proceeds toward the right, not spontaneously, but only when heat is supplied. On the other hand, the effect of pressure is to tend to remove the olefines from the sphere of reaction by polymerization, while the paraffine hydrocarbons, by virtue of their stability, find exit by way of the condenser.

That the diolefines have an important bearing upon the formation of aromatics is shown by Davidson,[19] who believes that the diolefines present in the vapors may combine with ethylene to form benzol:

$$C_2H_4 + CH_2=CH-CH=CH_2 \rightarrow C_6H_6 + 2H_2 \qquad (7)$$

The effect of pressure should be considered from several angles. In the pressure still it has the effect of raising the temperature to the point where cracking takes place rapidly; furthermore it tends to increase

the yield of liquid hydrocarbons in the gasoline range by *symmetrical scission* of the molecule; and finally it causes the distillate to be less unsaturated. As the distillation proceeds the lighter products are removed as fast as formed. Those molecules which are decomposable at the lower temperatures disappear at the beginning, while the more resistant ones remain in the heated zone, where, by the nature of the operation, they are later modified as the temperature rises. This gives us the distinction between pressure distillation and "cracking" in the vapor phase only; in the former case the best results may be secured by means of *minimum* "cracking" temperatures, while in the latter case *maximum* "cracking" temperatures generally must prevail in order to secure the desired results, as the entire oil (in vapor form) is subjected to the action of heat for only a limited time. The effect of these conditions on the character of the distillate will be discussed later.

The conditions just mentioned as being peculiar to "cracking" in the vapor phase only are modified to some extent by placing expanding drums at the outlet of the coils, where cracking is permitted to continue by heat carried along with the vapors or formed by the reduction of their speed.

THE ACTION OF CATALYSTS

As a means of improving the quality of cracked distillates the method of hydrogenation, which has been so successful commercially for the production of solid fats from those which are normally liquid, suggests itself as a likely method. Hydrogenation of cracked distillates with nickel as a catalyst is made difficult in the case of petroleum for some reason not well understood.[20] That hydrogenation at lower temperatures without a catalyst does not take place may be illustrated by the following experiment, carried out in the laboratory of the Mellon Institute: A sample of cracked naphtha of iodine value 51 was heated and stirred in the presence of hydrogen at a pressure of 3,000 lb. to the square inch and a temperature of 165 deg. C. for 30 hours, with the result that the iodine value was practically unaffected. If hydrogenation of olefines is to take place during cracking, it must evidently be at the time of their formation.[21]

At higher temperatures (above 200 deg. C.), nickel, platinum and palladium evidently catalyze the reverse action whereby hydrogen is removed from naphthenes, partially or completely.[22] In fact, it has been shown[23] that in the presence of nickel at 600-700 deg. C., Russian crude oil gave only coke and saturated gas composed of hydrogen and methane.

It is interesting to note here the work of Jackson and Lawrie,[24] who claimed that acetylene by the action of high-frequency electric discharge gave a solid polymer which, upon heating, decomposed to methane and liquid hydrocarbons; Losanitsch,[25] who exposed isopentane to the action of the silent electric discharge in vacuo and claimed the formation of hexamethyl

[16]*Arch. Sci. phys. nat.*, vol. 44, p. 400 (1917).
[17]Brooks and Humphrey, *J. Ind. Eng. Chem.*, February (1916).
[18]*J. Inst. Pet. Tech.*, vol. 3 (1916), p. 36.
[19]*J. Ind. Eng. Chem.*, vol. 10 (1918), p. 901. The reaction is characteristic of high temperatures.

[20]Brooks and Humphrey, *J. Am. Chem. Soc.*, vol. 40 (1918), p. 822. On the work of Ellis see *J. Ind. Eng. Chem.*, vol. 7 (1915), p. 1029.
[21]Brooks, Bacon, Padgett and Humphrey, *J. Ind. Eng. Chem.*, vol. 7 (1915), p. 180. Whitaker and Leslie [*J. Ind. Eng. Chem.*, vol. 8 (1916), p. 593] conclude that the absorption of hydrogen is greater as the temperature increases, rate of oil flow decreases, and concentration of hydrogen increases.
[22]See Ubellohde and Woronin (*Petroleum*, Berlin, 1911, pp. 7, 9), also Zelinski (*Ber.*, 1912, pp. 45, 3678).
[23]Ostromisslenski and Bujanadsa, *J. Russ. phys.-chem. Ges.*, 1910, p. 195.
[24]*Proc. Chem. Soc.*, vol. 22 (1906), p. 155.
[25]Mentioned by Dunstan and Thole, *J. Inst. Pet. Tech.*, vol. 3 (1916), p. 36.

cyclobutane, also noting the rapid polymerization of olefines and aromatic hydrocarbons; Beilstein and Kurbatow,[25] who secured dinitrobutane by nitrating a petroleum fraction boiling between 40 and 50 deg. C.; and finally Gurwitsch,[27] who reports that florida earth and alumina will cause polymerization of olefines, even at ordinary temperatures and pressures.

In certain patents the presence of substances such as coke, iron scrap, alumina, lime, copper, etc., is specified as catalysts to be placed in the cracking zone, the oil sometimes being mixed with steam before entering. If any beneficial action results from these substances it can be attributed more to surface action than to anything else. Davidson[28] states that iron, cobalt and nickel catalyze the reaction wherein paraffine hydrocarbons are decomposed into carbon and hydrogen.

TABLE II. RESULTS OF THE CRACKING OF TEXAS SOLAR OIL AT ATMOSPHERIC PRESSURE

Contact Substance	Per Cent Boiling Below 150 C.	Temp. Deg. C.	Time in Hours	Per Cent Loss Gas and Coke
None	8.3	500	0.5	8.7
Pumice	8.8	420	2.0	12.8
Pumice	15.6	500	2.0	17.5
Nickel wire	12.3	500	2.5	1
Nickel wire	18.8	500	5.0	16.5
Nickel on Al₂O + H	10.5	500	2.5	15.1
Nickel on Al₂O₃ + H	17.9	600	2.0	30.8
Copper on charcoal	14.7	500	2.0	13.1
Copper on charcoal	9.4	450	6.0	12.0
Copper gauze	14.1	500	2.0	11.4
Copper gauze	15.2	500	2.5	11.8
Copper gauze	18.8	500	4.5	17.1
Copper gauze + H₂O	15.5	600	2.0	11.1
Iron	4.5	400	2.7	....
Iron + H₂O	8.6	450	2.0	....
Iron + H₂O	8.5	480	3.5	....

In the laboratory of the Mellon Institute,[29] it was found that the "cracking" effect "produced in a given quantity in a given time was approximately proportional to the heated surface in contact with the oil," so that if certain metals which are good heat conductors are attached to the apparatus in such a way that heat be transmitted to the oil through a larger surface, advantages might result. An interesting table of experiments in which Texas solar oil vapors were passed over various contact substances is given in Table II.[30] It should be noted that the use of these substances is not to be designated as additional "heating surface," but rather as additional "surface effect."

The statement that the "cracking" effect is proportional to the heated surface in contact with the oil must necessarily be modified when the basic principle of the process is the use of superheated fluids such as steam or waste furnace gases.

THE DEPOSITION OF COKE DURING PYROLYSIS

It has already been mentioned that one of the most serious difficulties encountered during "cracking" is the deposition of coke. Unless removed from the walls of the apparatus very soon after its formation, the coke produced becomes very hard and is difficult to remove. Superheating (hot spots), consequent softening of the metal and finally "blowing out" may be the result of this condition. A majority of the processes include, among other things, methods of eliminating the coke from the heating surface. Thus the Burton process involves a modification in which false

bottoms are used, the Rittman process a revolving rod and chain, the Bacon process vertical heating surface in the presence of liquid,[31] and so on.[32] One patentee specifies the use of steel balls which are passed intermittently through the "cracking" coil.

It is becoming the practice to utilize heavy distillates for the purpose of cracking rather than the residual oils. In this way the amount of coke produced during the operation is materially lessened. For example, a heavy asphaltic oil may be distilled to coke at atmospheric pressure and certain of the distillates used for the purpose of cracking.

While coke is always formed during "cracking" and is likely to cause trouble if permitted to collect on the heating surfaces, the writer does not wish to convey the idea that "cracking" is always a wasteful process. In carefully operated and properly designed pressure stills using distillates as a starting material, it is claimed that the yield of coke, figured in percentage or original oil charged, is almost a negligible factor, and that the total loss during operation is less than 3 per cent of the original charge. In fact, a "cracking" process in a refinery equipped to separate the crude oil completely into its products consumes less useful or "waste" products, and transforms them, largely, into the more useful product gasoline. The density of the charging material for the pressure stills corresponds to that of gas oil, but is, in fact, a mixture of "odds and ends" from various processes in the refinery.

The analysis of pressure-still coke usually shows rather considerable quantities of iron sulphide.

THE COMPOSITION AND REFINING OF "CRACKED" DISTILLATES

Unrefined "straight run" or "natural" gasoline distillates are composed of varying proportions of paraffines, naphthenes, aromatics, small percentage of olefines and a quantity of organic nitrogen and sulphur compounds generally small, but depending upon the character of the original crude petroleum. Oxygen compounds such as naphthenic acids may also be present in traces. Some of the straight run gasolines which have been secured where direct steam was used in the distillation process require little or no treatment with sulphuric acid.

The gasoline distillates produced by "cracking" contain diolefines in addition to the compounds mentioned above, while the proportions of aromatics are larger.

Mr. Jenkins has subsequently submitted to the writer the following data secured from a run which may be considered as more nearly representing average results:

Time of operation (including heating up), 56½ hr.

Fuel used, 175,975 cu.ft. of natural gas [1,000 B.t.u. at 2½-lb. pressure (gage)].

Total oil charged, 44,467 gal. (gas oil, 33.4 Bé.).

Products:

Gasoline (56-58 deg. Bé., 130 i.b.p., 450 end point), 29.19 per cent.

Naphtha (48 deg. Bé., 470 end point), 9.13 per cent.

Kerosene distillate (39-40 deg. Bé.), 31.98 per cent.

Gas oil (35 deg. Bé.), 3.66 per cent.

Pressure still bottoms (24-26 deg. Bé.), 20.70 per cent.

[25] Ber., 1881, p. 1620.
[27] J. Russ. phys.-chem. Ges., vol. 47 (1915), p. 827.
[28] J. Ind. Eng. Chem., vol. 10 (1918), p. 901.
[29] Brooks, Bacon, Padgett and Humphrey, J. Ind. Eng. Chem., vol. 7 (1915), p. 180.
[30] Brooks, J. Frank. Inst., December, 1915, p. 653.

[31] The deposition of coke on vertical surfaces is only about one fifth the amount found on horizontal surfaces.
[32] In some refineries it is the practice to simultaneously agitate the oil slightly and to scrape the bottom of the still by means of a sweep with chains attached. In the Jenkins apparatus the oil is circulated rapidly by means of a propeller.

Coke, 1.5 per cent.

Uncondensed gas and other losses, 3.84 per cent.

Cracking in the vapor phase only, because of the higher temperatures generally employed, produces larger proportions of unsaturated hydrocarbons and aromatics than in the case of the pressure still.[33] Cracked distillates upon standing may precipitate a resinous product, which is derived, no doubt, from the diolefines and possesses explosive properties when heated.[34] The disagreeable odor of these distillates is attributed by some to the unsaturated hydrocarbons, particularly the diolefines. Brooks and Humphrey,[35] however, record that this disagreeable odor is to be attributed more to the presence of organic nitrogen, oxygen and sulphur compounds.

Su'phuric acid acts both chemically and physically upon unrefined distillates, colloidal coloring matter being precipitated and dissolved by the acid, unsaturated hydrocarbons, nitrogen, sulphur and oxygen compounds entering into reaction, the last two mentioned being by no means completely removed. The rise in temperature which is especially marked in the case of unrefined "cracked" distillates when treated with sulphuric acid is no doubt due mainly to the diolefines. According to Brooks and Humphrey, the lower olefines react to form alkyl esters, tertiary and secondary alcohols, some polymerization also taking place. Above the hydrocarbon $C_{12}H_{24}$ polymerization takes place to form di- and tri-polymers which contain but one double bond. In the case of gasoline distillates these polymers dissolve mainly in the hydrocarbon layer, raising the final boiling point.

Likewise, neutral esters of sulphuric acid remain in the gasoline and are not removed when the product is washed with alkali solution; upon standing, the product is likely to precipitate a resinous, viscous layer due to these esters.

It is well known that "cracked" distillates are more difficult to refine successfully than the "natural" products. The loss is likely to be large and the resultant product may be colored, this color tending to deepen upon standing. Ellis and Wells[36] report that by hydrogenation of "cracked" gasoline was secured a water white product, but they do not give the specific method used nor the constants for the gasoline before and after treatment. Brooks and Humphrey[37] recommend that the unrefined product be treated with not more than 6 per cent of 85 to 90 per cent sulphuric acid fo'lowed by redistillation. The writer and his students find that the best results, both so far as *color* and *odor* are concerned, were secured by treating the cracked gasoline distillate with concentrated sulphuric acid (1.84 sp.gr.) at from 32 to 40 deg. F., followed by redistillation and washing with dilute alkali[38] or sodium plumbite solution.

In the refineries it is customary to mix the pressure distillate with a large excess of straight run naphtha followed by acid treatment and finally redistillation. In this way a satisfactory product is secured.

For purposes of comparison, constants for crude pressure still gasoline and crude straight run gasoline, both from the same crude oil mixture, are given below:

Constants	Crude Straight Run Gasoline	Crude Pressure Still Gasoline
Gravity, Bé. degrees (mod. 140)	57.7	54.3
Refractive index (60 deg. F.)	1.4142	1.4252
Heat of reaction with sulphuric acid (1.84 sp.-gr.), deg. F.	2.5	11
Loss to sulphuric acid at room temp., per cent.	9	16
Loss to sulphuric acid at 32 deg., per cent.	5	8

The writer is indebted to W. A. Hamor and W. F. Faragher for many valuable suggestions and assistance in preparing the foregoing article as well as one describing the several processes in commercial use, which is to appear in this journal at an early date.

The Finnish Tar Industry

For the year 1919 the Finnish tar production has been roughly estimated at not more than 50,000 hectoliters, with a value of approximately 8,000,000 marks. Import and export statistics are given below for the whole of 1919 and for the first three months of 1920:

Tar Products	1919 Amount	1919 Value Marks(a)	1920 (January-March) Amount	1920 (January-March) Value Marks(a)
Exports:				
Tar, hectoliters	11,638	2,604,031	(b)352,789	734,749
Rosin and resin, pounds	789,000	1,459,629	54,800	100,858
Turpentine, pounds	94,600	312,396		
Imports:				
Tar, hectoliters	25,794	3,041,709		
Rosin and resin, pounds	3,124,000	5,135,862	1,892,700	5,421,485
Turpentine, pounds	39,600	143,772		

(a) The par value of the Finnish mark is 19.3 cents.　(b) Kilos.

Practically all tar exported from Finland is wood tar, while the imports consist of coal and asphalt tar. The great decrease in the tar production of 1919 is attributed to export restrictions and uncertain prices. Such restrictions did not exist in 1918, and as a result production was very high that year. It is said that America is the only country at present in which there is a great demand for tar, but the high cost of transportation prohibits its shipment there, the freight rates being almost as much as the price of the tar itself. Practically all the tar produced now is for domestic use. The high cost of production and the depreciation of the Finnish mark are great handicaps to the industry, and the outlook for 1920 is very discouraging. Until prices stabilize and export restrictions are removed production will continue to be low.

Drop in Chemical Trade at Hongkong During 1919

There was little life in the trade in chemicals at Hongkong during 1919, and the United States played a minor part in what trade there was, though efforts were made during the year to secure supplies in some important lines from American manufacturers. The value of the trade increased from $2,264,149 in 1918 to $2,572,755 in 1919. Imports of saltpeter, which is the heaviest item in the list, were valued at $459,659 and came from India. There were practically no imports of saltpeter in 1918, the export from India being prohibited. Imports of soda ash were valued at $228,342, compared with a value of $120,014 in 1918, and came almost entirely from Great Britain. Caustic soda reached a value of $194,696, compared with a value of $210,411 the previous year. Two-thirds of it came from the United States and the rest from Great Britain. There was a decrease in the import of acids, most of which came from Japan. Bleaching powder, calcium carbide, phosphorus and glycerine showed decreases, while imports of alum, borax, quinine, chlorate of potash and sulphur were increased.

[33]In the presence of steam it is claimed that a sweeter product is secured. See, however, Brooks, *J. Frank. Inst.*, December, 1915, p. 659, and Davies, *J. Ind. Eng. Chem.*, vol. 8 (1916), p. 114.

[34]See Ellis and Wells, *J. Ind. Eng. Chem.*, vol. 7 (1915), p. 1029.

[35]Brooks and Humphrey, *J. Am. Chem. Soc.*, vol. 40 (1918), p. 822.

[36]*J. Ind. Eng. Chem.*, vol. 7 (1915), p. 1029.

[37]*J. Am. Chem. Soc.*, vol. 40 (1918), p. 822.

[38]The loss under these conditions should be about half that at average atmospheric temperature.

Data on Operation of Continuous Type Lime-Soda Ash Water Softener

By R. F. Catherman and H. C. Fisher

A NUMBER of articles have been published from time to time, giving the theory and practice of water softening, using the intermittent system. The following remarks are of different nature and discuss the problems encountered in the operation of a continuous water softener using lime and soda ash as the precipitating agents. The information given here was gained during the operation of a Booth Continuous Water Softener during a period of six months, sixteen hours per day. Before the operation of the new West End power station of the Union Gas & Electric Co., Cincinnati, Ohio, power was generated at the old Plum St. station, which was situated on the Miami and Erie Canal, the waters of which were used for boiler feed and condensing purposes. The apparatus mentioned was used to prepare
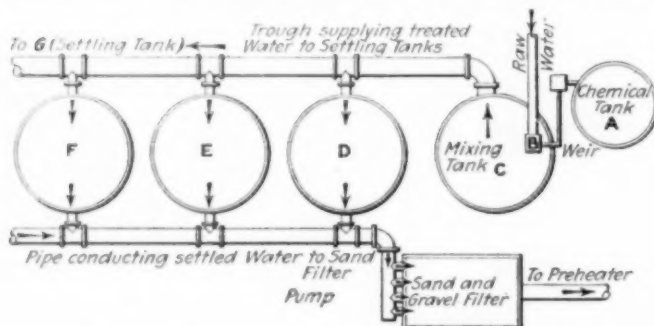
FIG. 1. CONTINUOUS TYPE WATER SOFTENER

water for the boilers, a task that was difficult because of the many variable factors entering into it.

The general layout of the plant is shown in Fig. 1. Water from the canal entered the mixing tank C from the automatic weir B, where chemical solution from tank A was pumped through B into tank C. The treated water then passed along a trough to settling tanks D, E, F and G, after which it was forced through
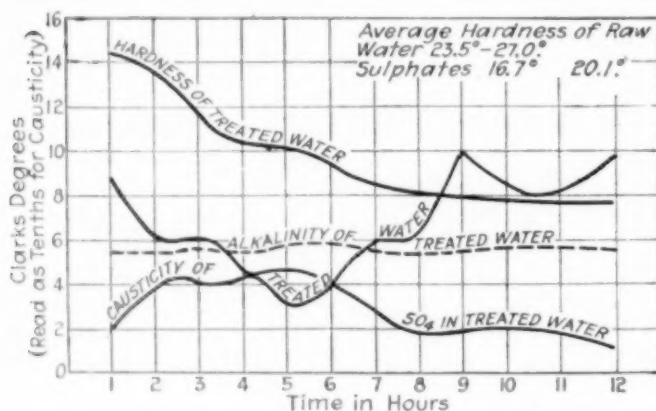
FIG. 2. SYSTEM BEING BROUGHT TO EQUILIBRIUM

a sand filter and up into a preheater. Specific dimensions have no particular bearing on the discussion and will, therefore, be omitted. (Capacity of softener—14,000 gal. per hr.)

WATER SUPPLY VARIABLE

The fundamental part of the whole system was the weir, which was so arranged as at all times to admit 650 parts raw water to 1 of chemical solution, by volume. Theoretically, knowing this relation and the con-

stitution of the raw water, the necessary charge can be calculated. However, this was not practical, considering the raw water from the canal. This stream was used as a means of sewage disposal by a large number of industrial firms in the Mill Creek Valley, such as tanneries, dye works, soap factories, distilleries, etc. Using
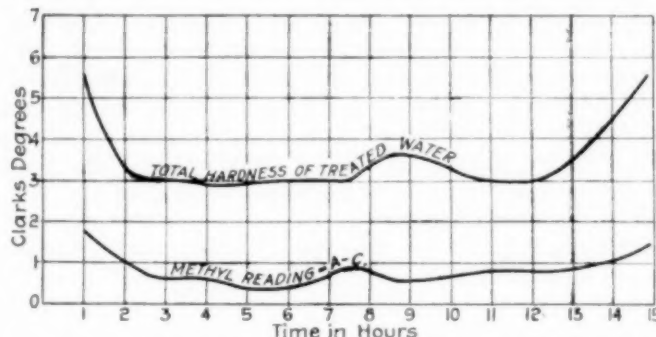
FIG. 3. VARIATIONS IN TOTAL HARDNESS WITH CHANGES IN METHYL READING

Clark's soap solution, which was considered sufficiently accurate for the purpose in hand, the hardness of the raw water was found to vary widely between 15 and 40 deg., a constant condition never being maintained. Sulphates usually constituted 50 per cent of this total hardness. Analysis showed calcium, magnesium, barium and iron to be present in amounts decreasing in the above order. Besides these minerals, large amounts of organic matter were present, sometimes to such an extent that the quantitative analysis was rendered very difficult. As will readily be seen, the above conditions, combined with extremely variable loads on the system, presented a difficult problem in softening the water.

ANALYTICAL DATA DETERMINATIONS

Assuming that the reader is acquainted with the chemistry of water softening, using the lime and soda ash method, the quantitative reagents will be discussed. The total hardness of the treated water was found, using Clark's soap solution so standardized that 1 c.c. was equivalent to 14.3 parts of hardness per million parts of water, expressed as $CaCO_3$. Titration of a sample of 100 c.c., using hydrochloric acid of Clark's degree strength and phenolphthalein as an indicator, gave the causticity or C reading. Further addition of methyl orange and continued titration gave the alkalinity or A reading. The difference between them, $A - C$, was termed the M or methyl reading. Since the water was acid in character, these readings were obtained on the raw water with the exception of C.

INTERPRETATION OF DATA

As before stated, the variable factors in the system made it impossible to calculate the chemical charges. Upon assuming control of the plant, therefore, experiments were performed to obtain relationships between the H, C and M and the A readings. Fig. 2 shows the relations during a period when the system was being brought to equilibrium. It shows that as the hardness decreases, the M reading approaches a value that is constant for any given raw water. Considering another typical period as shown by Fig. 3, it is seen that as M deviates markedly from the equilibrium value of that particular water, H rises. Explanation of these facts may be as follows: Hydroxyl ion must be present in amount sufficient to precipitate all bicarbonates and still provide a slight excess over this amount. By the law

of mass action, this excess increases the precipitation and also provides for any sudden increases in the temporary hardness of the raw water. During the above period, Na$_2$CO$_3$ is removing the sulphates, and is also provided in slight excess. Consider a case when the hardness of the raw water is decreased, both temporarily and permanently in approximate proportion. Such a case indicates that the excess chemicals cause the production of hardness, the CaCO$_3$ forming a gelatinous precipitate

$$Ca(OH)_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaOH$$

Too large an accumulation of carbonate precipitate in the settling tanks was always accompanied by an increase in hardness despite the condition of the causticity and alkalinity, hence the justice of the above statement
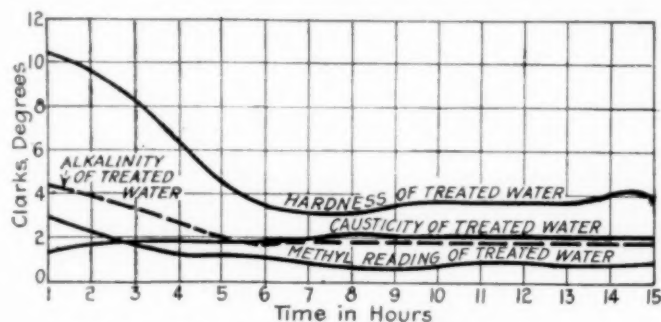
FIG. 4. SYSTEM APPROACHING EQUILIBRIUM

seems established. The excess NaOH gives rise to a high C reading, which, when combined with the high H and A, instantly showed that a too large excess existed, and steps were always taken to remedy the condition. Partial drainage of settling tanks always facilitated matters, at the same time preventing a high alkalinity.

CALCULATION OF LIME AND SODA ASH CHARGES

Formulæ for the calculation of charges, as given by the designers of the plant, were based upon the findings of the American Public Health Association. These principles are sound, but must be interpreted with great care in all cases. The specific directions given were somewhat fallacious, as proved by long periods of inefficient operation experienced in their use. As mentioned before, there was an equilibrium point which marked the lowest attainable hardness. This point was defined by the titrations, the methyl reading being the most significant. Efforts were always bent toward keeping the hardness between 3 and 4 deg. Clark. In this range of hardness, as shown in Fig. 2, the typical readings were identified by methyl readings averaging from 0.6 to 0.8 deg. Of course, it must be understood that the constant changes in the constitution of the raw water made actual calculations and results variable, but examination of typical report sheets shows the truth of the statement. Since direct calculations were not feasible, resort was made to the data for a solution of a different type. Taking a problem for explanation, let the following be the conditions:

	Treated Water					Charge			Lime, Lb.- Ft.	Soda Lb.- Ft.
Time	H	C	M	A	Time	H$_2$O, In.	Lime, Lb.	Soda, Lb.		
7.40 a.m.	8.7	0.9	1.6	2.5	8.15 a.m.	12	165	32.0	165	32.0
9.20 a.m.	8.9	1.5	1.1	2.6	9.40 a.m.	6	92.5	27.5	185	55.0
10.50 a.m.	7.5	1.2	0.8	2.0	11.10 a.m.	6	100.0	30.0	200	60.0
1.00 p.m.	4.7	1.0	0.8	1.8	1.15 p.m.	6	108.5	30.0	217	60.0
					(and so on through the day)					

Calculations were found to obey the following proportions, in which the only factors that entered were those concerning the condition of the treated water, an obvious fact since the condition of the raw water is reflected in that of the treated water. In fact, the hardness of the raw water was only used as a comparative basis for the approximation of the charges needed when starting the operation of the plant after having, for some reason or other, had it out of service. As found, $C = 0.9$ deg., $M = 1.6$ deg., and $A = 2.5$ deg.; therefore knowing that that value of C is too low and that the value needed is probably 1.5 or a similar one, the ratio of these values is equated to the ratio of the last charge of lime to the unknown one. (All charges based on foot depth of chemical tank.)

$$\frac{Existing\ C}{C\ necessary\ for\ equilibrium} = \frac{Last\ charge\ of\ lime}{New\ charge\ of\ lime} \quad (1)$$

Knowing also that the equilibrium value of M is a fixed quantity, the next step is to form a ratio between values of M in a similar manner.

$$\frac{Existing\ M}{C\ necessary\ for\ equilibrium + correct\ M} =$$
$$\frac{Last\ charge\ of\ soda}{New\ charge\ of\ soda} \quad (2)$$

Evaluating the above:

$$\frac{0.9}{1.5} = \frac{100.0}{x} \quad x = 166\ lb.\ lime \quad (1)$$

$$\frac{2.5}{2.3} = \frac{35.0}{x} \quad x = 32\ lb.\ soda\ ash \quad (2)$$

The variations from the actual calculated results, as seen in parts of the given tables, emphasize the personal equation which enters the operation of a continuous type water softener.

EXPERIMENTS WITH NaOH

During a period of three days experiments were tried with the use of sodium hydroxide as the softening agent. The theory leading to the use of caustic soda was based
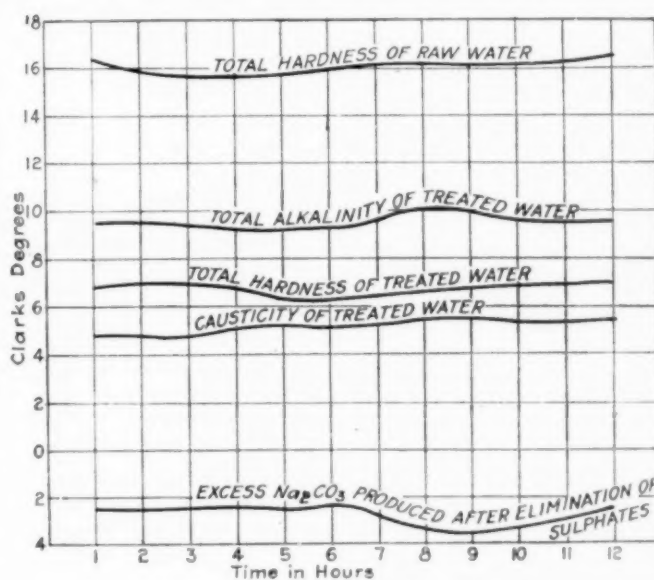
FIG. 5. SYSTEM AT MAXIMUM EFFICIENCY

on the consideration that the bicarbonates would be precipitated by the hydroxyl ions, as happens with the use of caustic lime, producing simultaneously sodium car-

DAY OF BEST EFFICIENCY (USING NaOH)

Raw Water				Treated Water								Charge H₂O, Soda.			Filter Temp.	
Time	H	M	SO₄	Time	H	C	M	A	HCO₃	OH	CO₃	Time	In.	Lb./Ft.	Time	Deg. F.
7.30 a.m.	16.4	7.8	8.6	7.40 a.m.	6.8	4.8	4.6	9.4	0.0	0.2	9.2	8.15 a.m.	24	110	8.00 a.m.	84
				9.15 a.m.	6.8	4.6	4.8	9.4	0.0	..	9.2	No charge			10.00 a.m.	85
				10.30 a.m.	6.7	4.8	4.4	9.2	0.0	0.4	8.8	No charge			12.00 m.	84
10.40 a.m.	15.5	8.0	7.5	11.15 a.m.	6.6	5.0	4.2	9.2	0.0	0.8	8.4	No charge			2.00 p.m.	86
				11.50 a.m.	6.6	5.0	4.0	9.0	0.0	1.0	8.0	No charge			4.00 p.m.	89
				1.15 p.m.	6.3	5.0	4.6	9.6	0.0	0.8	9.2	No charge			6.00 p.m.	78
1.20 p.m.	16.0	8.6	7.4	2.30 p.m.	6.4	5.3	4.8	10.0		0.4	9.6	3.50 p.m.	18	105	8.00 p.m.	80
				5.00 p.m.	6.5	5.2	4.4	9.6	0.0	0.8	8.8	No charge			10.00 p.m.	79
				7.00 p.m.	6.9	4.4	5.0	9.4	0.0	..	10.0	No charge				
				8.30 p.m.	6.8	5.0	4.8	9.8	0.0	0.4	9.6	9.45 p.m.	18	105		

bonate, which would react with the sulphates present, thus removing them.

$$Ca(HCO_3)_2 + 2NaOH \rightarrow Na_2CO_3 + CaCO_3 + 2H_2O$$
$$CaSO_4 + Na_2CO_3 \rightarrow CaCO_3 + Na_2SO_4$$
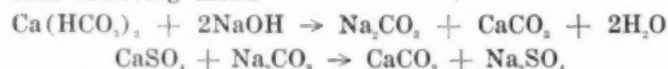
The comparative success of the experiment suggested a few questions:

At what period during the experiment was precipitation of sulphates initiated?

What was the behavior of the causticity? The alkalinity?

What factor controlled the lowest attainable hardness?

Examination of Fig. 4 shows that the permanent hardness was precipitated from the beginning of operations, that no hydroxyl was present at that time, and that as the causticity increased the total hardness diminished and the alkalinity remained constant. Applying the correct formula, it is seen that for the system approaching equilibrium the HCO_3 averaged 5 deg. as the SO_4 decreased from 8.9 to 1.4 deg. The day of best efficiency is shown in Fig. 5. Since that day is typical, the calculations are given in the accompanying table.

The large carbonate readings are attributed to the total elimination of sulphates and the consequent production of excess Na_2CO_3. Owing to the many factors entering the system, nothing specifically numerical can be stated concerning this. One outstanding fact is presented by the data—namely, that if a constant charge can be used after reaching the equilibrium point, the total alkalinity will not increase. An increase in the concentration of the charge, after reaching that point, is accompanied by a rapid increase in the alkalinity.

Union Gas & Electric Co.
Cincinnati, Ohio.

Gas Appliance Investigations by the Bureau of Standards

The investigation of gas-burner design and operation, begun last year in co-operation with the industrial fuel committee of the American Gas Association, has been continued actively throughout the year. This work is an essential preliminary to investigations which have been in mind for several years looking toward increased efficiency in the use of gas. The proper design of air shutter, gas orifice and burner throat to give the maximum injection of air under ordinary conditions was the part of the problem particularly assigned to the bureau. Some months were spent in designing and developing suitable apparatus for making the necessary measurements of the air and gas, but the time thus spent was well worth while, as the equipment developed proved so satisfactory that results have been obtained with unusual rapidity. This work has been done on experimental burners representing a wide variation in dimensions.

Discontinuance of Crude Camphor Export Allotments by Japan

The Japanese authorities have decided to discontinue the allotment of crude camphor to camphor refiners in the United States and other countries foreign to Japan. This step has been taken as a measure of relief to the Japanese camphor refiners, who are in serious straits, owing to the depression in the celluloid industry. Japanese camphor refiners are concerned with nothing but camphor, while it is understood American camphor refiners are concerned with that product only as one of a number of others with which they can keep their plants busy. It is therefore believed that American camphor refiners will not be especially inconvenienced.

In order to offset any possible loss, the authorities have decided to allot to refiners in the United States, at a special discount, 15,000 lb. of refined camphor a month. During the year ended March 31, 1920, only about 64,000 lb. of crude camphor was allotted to camphor refiners in the United States. A much greater quantity of the refined, however, is allotted, so that American refiners may, with the special discount and the greater quantity, obtain at least their usual profit for handling camphor. The price for refined camphor is 290 yen ($144.56) per 100 lb.

This action does not alter in any way the allotments of "B" and "BB" grade camphor to celluloid manufacturers. In fact, the authorities are hopeful of being able to increase production during the fall and winter of this year so that allotments to celluloid manufacturers may approach nearer the maximum figures than has hitherto been the case.

New Electric Power Plants in Italy

In the territory of Treviso the Società Adriatica di Elettricità, together with the Società del Cellina, is running two hydro-electric power plants, which are situated at Fadalto and Nove, on the lakes of Santa Croce and Morto, capable of producing, respectively, 20,000 and 8,000 hp.

On account of the unusual demand for electric energy for illumination, industries, drainage installations and agriculture, due largely to the prohibitive price and scarcity of coal, these two societies have decided to immediately execute a program for augmenting their production, and both are working at present in order to transform their plants and increase their production to approximately 280,000 hp.

Once the work is accomplished, they will dispose of 700,000,000 kw. of energy, in comparison with 32,000,000 kw. at present, which would mean a saving for Italy of about 1,000,000 metric tons of coal per year.

To carry out the program the societies will have to spend about 220,000,000 lire in five or six years.

Practical Notes on the Design and Treatment of Steel Castings*

A Discussion of Foundry Practices Necessary to Avoid Cracks, Draws, Honeycombing, Cavities and Such Defects—The Importance of Heat Treatment Is Emphasized, It Being Noted That Correct Methods Give Castings Equal to Forgings in Physical Properties

By GEORGE F. PRESTON

IT IS much to be regretted that, between engineers and steel-founders, there is so little interchange of the knowledge gained by experience on the subject of the production and treatment of steel castings, a subject of very considerable importance, as greater reliability in steel casting would result from a better understanding of requirements and difficulties by users and suppliers.

Steel castings are used extensively for very diverse purposes. Some difficulties which have arisen in the foundry have been due to the non-appreciation of the fact that, at the recalescence point Ar_3 in the cooling curve of steel contraction is arrested and an actual expansion takes place. In an ordinary 0.3 per cent carbon

Section at a. b.

FIG. 1. CYLINDER WITH DIFFICULT BED PLATE

steel the expansion between 690 and 650 deg. C. is approximately equal to the amount of contraction between 790 and 710 deg. C.; therefore in some castings of intricate design reversals of stress do not occur simultaneously in all parts. If such castings are left in the sand or on the floor, cooling at unequal rates in various parts, contraction will be taking place in some portions, while in others expansion will occur, when adjacent members are in a plastic or weak condition, resulting in pulls or cracks. When such difficulties due to reversals of stress occur, modification in design, so as more nearly to equalize the thickness in critical parts, affords one means of remedy. Another is by chilling or using one of the various methods, not altogether looked on with favor by the engineer, for making the thicker sections cool more rapidly where feasible, or, for any other reason, not undesirable.

USE OF CHILLS

Most steel-founders have probably experienced cases where the use of chills has been followed by cracks in the casting, through the effect of using such chills not having been fully considered. An alternative method which might be adopted for some castings is to arrange for the cooling from a temperature above 770 deg. C. to take place in a preheated furnace, care being taken to strip the casting at a temperature sufficiently above

this to enable it to be sealed up in the furnace before the temperature has fallen to the danger point. This method was adopted with success in the case of a casting for a ship of world-wide repute, having a heavy flange, or seat, about the middle of its length, after several unsuccessful attempts had been made to obtain a satisfactory casting by other means.

Cases occur where the engineer would be put to increased cost, or experience a difficulty, by omitting some portion objected to from the founder's standpoint, as, for example, in a cylinder or tube such as that shown in Fig. 1, having a heavy flange, XX', 2 to 4 ft. from the mouth, and used only for bolting the cylinder on to its bed plate, which present two difficulties to makers. One is to feed the square flange to insure soundness; the other, which is possibly of more consequence, is to prevent pulling in the bore of the cylinder about the center of the width of the flange at A. In such cases probably no really serious objection could be raised to introducing in this heavy flange a frame (Fig. 2), previously cast in steel, to act as a chill, thus equalizing the rate of cooling and also insuring an absence of cavities in the surrounding metal. There would be little theoretical and probably no practical loss of strength, as unless the chill was of excessive thickness it would to a large degree be fused by the fluid steel.

FEEDING HEADS

In the case of important castings subjected to severe stresses, such as large gun mountings, etc., the fullest and most careful consideration should be given by the designer to the placing of heavy masses or sections of
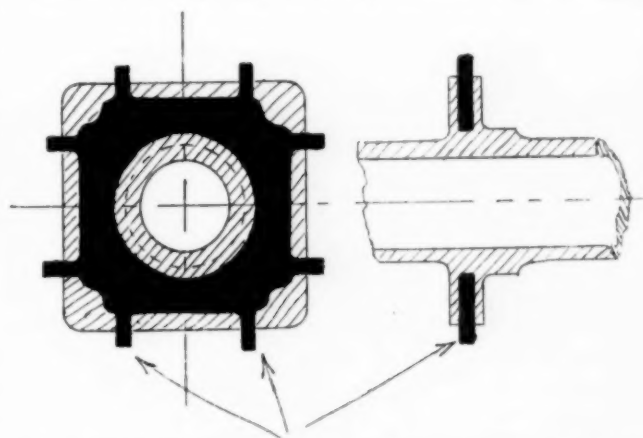
FIG. 2. SUGGESTED CHILL FOR FIG. 1; TO BE PREHEATED

metal where adequate arrangements can be made for feeding, as, in the absence of feeding heads, the thinner surrounding sections will draw on such reservoirs of molten steel and result in unsoundness or piping in

parts where it is of the utmost importance that a large factor of safety should be provided.

The making of a ship's stem free from defects might be instanced as an illustration of this important point as to the position and size of necessary feeding heads, to insure soundness, or, on the the other hand, of alteration in design to obviate them—a problem which, owing to the great divergence in the types of castings required by users, is relatively more difficult of general solution (even if not of the same importance) than the recently much discussed question of producing sound ingots.

Such a casting usually has heavy brackets cast between the webs at the deck positions, large radii, advisedly, being usually formed, thus further increasing the relative mass at these places. There is little doubt that a more satisfactory casting would result (even if, superficially considered, such does not appear to be the case owing to unsoundness of piping not being apparent on the surface) by breaking the continuity of the junction of the bracket with the section of the webs, particularly at the extreme forward point, as such recesses in the deck brackets can safely be filled in later by electric welding and calked to make perfectly water-tight. If feeding heads are placed over these brackets, the steel will remain fluid at these places after the general contour of the stem casting has solidified, thus tending to unsoundness, distortion and troubles through contraction. Another point which should be borne in mind in connection with castings of this type is that during the period of cooling after casting the curved contour will tend to approximate to a straight line. Allowance should therefore be made by the pattern-maker for this tendency, particularly toward the two ends. When the annealing, or heat treatment, is carried out the contortion which would probably result if flames are allowed to impinge on the casting must be guarded against before the furnace is closed.

Modifications in design would be the more satisfactory expedient in some cases which come before the steel-
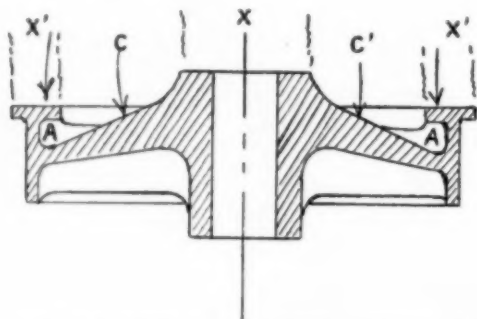
FIG. 3. WHEELS WITH RIBS UNDER INTERNAL FLANGE AND HEAVY CONE CENTER

founder, parts being made separately where possible. This has sometimes the objection of increase in cost of machining, etc., but cheapness should not be the sole consideration in making such castings.

Castings of the type shown in Fig. 3 are sometimes asked for, with light ribs, AA, tied under internal flanges and also to a heavy plate or cone center, CC'. Such ribs naturally cool at a much quicker rate than the heavy disk portion and feeding heads, XX', and are therefore in considerable tension, where the members join the periphery, when the plate portion and the center boss have reached their maximum contraction.

It is likewise a difficult matter to insure perfectly

satisfactory casting of such design as shown in Fig. 4. This shows a disk, or wheel, having spokes of heavy rectangular section on which are superimposed a plate of lighter section. Drawing or other defects will probably appear in the plate over the center of the spoke or rib (see X on section ab).

It must be admitted that a careful consideration by the management (and especially a joint discussion with all foremen responsible for seeing work through the different shops) of the problems to be faced in these and similar instances would conduce to the production of better castings; as it is sometimes seen, after a pattern is completed, that if it had been made differently in some respect, to allow of a modification in the method of making the mold, provision could have been more efficiently made for feeding, and also for guarding against contraction and other troubles.

Such expedients as the insertion of tubing of small diameter and of considerable length rammed with sand,
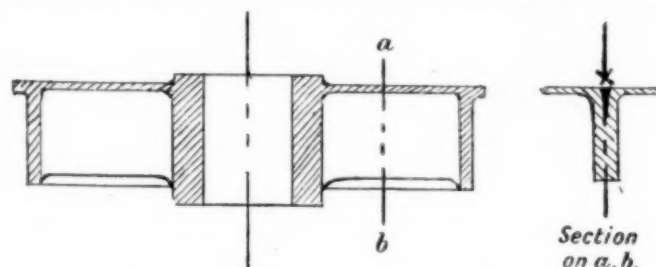
FIG. 4. "DRAWING" OVER DEEP RIBS

in lieu of cores where they are surrounded by large masses of steel—which cores would necessarily have to be made hard to stand and would become much more so through the contraction of the steel—would probably then be arranged for and much expense be saved in fettling and in the machine shop. It is well known that bent or broken cores cause endless trouble when the casting reaches the drilling machine; in fact, in many instances it would be far cheaper to omit small bolt-hole cores altogether.

There is also a danger of small cores in one plane (say for a number of bolt-holes) causing vital cracks in large castings of heavy section, owing to contraction, the cores becoming very hard and offering great resistance while the steel is semi-plastic.

HONEYCOMBING

Steel-founders of repute have overcome the trouble of honeycombing and blowholes in castings. These in earlier days were considered almost unavoidable, in fact it has been stated in the past that the presence of blowholes might be taken as a "guarantee of quality in other respects"!

Given steel properly melted and with suitable percentages of silicon and manganese, and care in making and drying molds, little trouble is experienced in this respect; piping, sand defects, etc., being far more frequently the cause of discards.

The elimination of honeycombing has resulted in very largely increased productions of cast steel blanks for machine-cut gearing and similar castings, on which a large amount of machining is done; but, owing to the serious loss which would be incurred if defects developed, particularly at a late stage in the machining operation, it is very necessary that everything which can possibly be done to insure perfection should be given earnest consideration. Arrangements should be made

for the fluid steel to enter the mold at the bottom, and whenever possible a centripetal action, commonly termed "spinning," should be secured. Suitable risers and feeders should be provided where necessary, to insure any dirt being brought up into the heads. It is usually advisable to cast such articles quickly.

Castings of this kind are frequently produced without the slightest defect, provided the design be favorable. One cause of trouble has been due to the founder being asked to supply blanks of fairly large diameter with solid disk, or plate, centers, which have a pronounced tendency, in large diameters, to result in cavities being formed in the rim, practically in the position where the roots of the teeth are when these are "milled" out. (Fig. 5). This is due to the rim being of heavier section than the disk and therefore remaining fluid longer, and also, in cases where the change in section is not so great, to difficulty in arranging for adequate feeding at this place.

It is preferable to adopt H-section arms, but it is then found expedient to break the continuity of the metal at the junction with the rim by placing a narrow
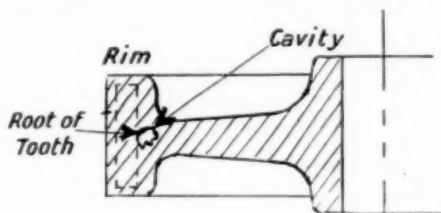
FIG. 5.   HONEYCOMBING AT JUNCTION OF RIM AND ARM

core through the webs of the arms. If objection be made to such a method resulting in any weakening of the casting, this can easily be obviated by increasing the strength of the faces, or top and bottom flanges, of the arms by having larger radii between them and the rim (see XX' Fig. 6), which is preferable from the founder's standpoint as well.

The same problems are encountered in the production of smaller castings, weighing from a few ounces upward, as supplied to motor and general engineering firms.

The difficulties might be overcome in many instances if it were possible to arrange to submit suggested designs to some steel-founder of good standing beforehand.

It is not intended, however, to convey the impression that all faults lie with the drawing-room, as by careful attention and thought on the part of the foundry staff better articles could be produced by judicious use of chills, feeders, etc. Further interchange of opinion would, however, undoubtedly lead to increased efficiency and obviate some of the troubles experienced by the engineer.

To give one example only: Axle-box guides for locomotives are still made as shown in Fig. 7A, which any user will understand generally results in "drawing" at X and X', in addition to causing extra work in the machine shop owing to the absence of tool clearances, instead of a more gradual change in section and also of radii at the corners, as illustrated by Fig. 7B, the more usual present design.

Innumerable examples might be adduced[1] affecting practically every type of steel casting made, but the desire at the moment is to persuade the engineer

---

[1]Hydraulic cylinders having square instead of rounded or spherical ends, for instance.

that exchange of views is of importance not only in respect of the production of castings without inherent weaknesses, but also in regard to the use of differing qualities of steel, or of special alloy steels, for various purposes.

The provision of suitable test-coupons, in the case of some forms of castings, is an important matter if sound pieces for tensile and bend tests are to be insured. This should not be left to the discretion of the molder, who is usually, in deciding where to place these, governed by considerations of convenience in respect to the molding-box used for the job. The question is well worth consideration by the management, owing to the loss incurred if a satisfactory casting be rejected solely through inability to obtain test-pieces free from defects. In some cases, on cutting up a casting for test to represent others produced from the same cast of steel, or on breaking it under the tup for remelting, it has been found that the casting was perfectly sound, defects appearing in the test-pieces only.

It is also highly advisable to provide for spare test-pieces, as cutting pieces from rising heads often results in disappointment from causes such as segregation.

Consideration should be given to such points as feeding the test-bars, and whether the steel is able to flow freely through the part provided for tests; whether any dirt carried off the face of the mold, etc., may be trapped, and whether the test-bar will be sound at the expense of unsoundness in the casting itself or *vice versa*.

For small castings it is advisable to treat the test-bar as a separate casting but connected by a "spray" of sufficiently large sectional area to insure that the test-piece is securely attached to the group of castings, or to the single casting, as the case may be, and also to give an adequate flow of steel into the test-bar, on which a separate feeding head should be superimposed. A suitable design of test-piece for this purpose is shown in Fig. 8.

The provision of test-pieces from small castings may add very considerably to the cost of production, especially in cases where only a few are required from a pattern. This should be borne in mind when quoting, and the most favorable arrangements made with the inspecting engineer as to including a quantity from one cast of steel as well as from a single molding box.
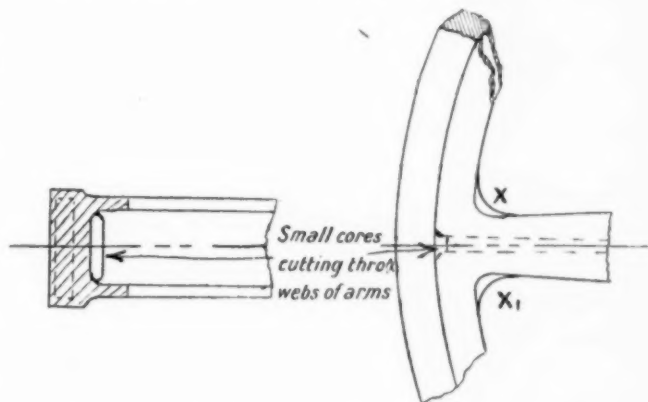
FIG. 6.   CORE AT JUNCTION OF H-SECTION ARMS

When molds are made by machines, it will be found convenient to arrange the patterns on the plate, whenever possible, so that one or more patterns can easily be removed and a test-bar included in place in several of the molds for each cast. Special attention must neces-

sarily be given to the method of fastening patterns to the plate to prevent any possible chance of displacement through the more frequent changing.

HEAT TREATMENT

To insure satisfactory test result it is necessary that the annealing or rather heat treatment (as the great majority of castings are now cast in mild steel and annealing—i.e., softening—to permit of the castings being readily machined was principally required for crucible steel castings) should be carefully carried out. It is very advisable to have some means of recording temperatures, reading being taken in various positions in larger furnaces; at any rate until it is ascertained that something approaching a uniform heat is obtained in the particular type of furnace in use. The furnace attendant, if left to himself, often appears specially interested in recording flame temperatures rather than those of the castings under treatment. If personal attention is given, by some one holding a responsible position, to this matter of heat treatment, economies in working, as well as higher quality material, etc., may result, as small modifications in furnace design—for instance, slight alterations in the sizes and positions of admission ports—may be found advantageous.

There is no doubt that an experienced workman can judge temperatures to within a reasonable variation, at

FIG. 7.   TROUBLESOME AND APPROVED DESIGN FOR AXLE-BOX GUIDES

any rate under the atmospheric conditions he is accustomed to, but it will usually be found that the tendency is to estimate the temperature higher at night than in daylight, and the cost of a pyrometer is money well spent.

The most satisfactory furnace is one in which the rate of cooling down at the critical temperature can be varied to some extent, as it is then possible to obtain small variations in the maximum stress where castings are made to stringent specifications.

Owing to the difficulty sometimes experienced in obtaining permission for material, which has given results, say, 4,000 to 6,000 lb. over or under the tensile strength specified, to be re-treated, it would appear that some engineers have not yet realized that the rate of cooling through the recalescence point of the steel governs the tensile strength, and that a substantial increase or decrease can be made by accelerating or lengthening the period of cooling through this range.

It is found in practice that heating to a temperature of about 950 deg. C. is advisable to insure the breaking down of the cast crystalline structure, the final structure of the ferrite and cementite being, of course, coarser or finer according as the rate of cooling through the critical range is slow or rapid. This temperature is much higher than is theoretically necessary, but experiments over a considerable period show the necessity for the higher temperature. The original crystallization of a casting

will, of course, be governed by the mass of metal, and the rate of cooling after casting either in the mold or, if knocked out, early after casting, on the foundry floor.

The length of time necessary throughly to soak castings and complete the breaking down throughout is a variable matter depending on size, thickness of metal, position the castings are loaded in the furnace, and probably several other considerations.

When dealing with large castings of heavy section it is advisable to pack them well up from the floor of the furnace. If this can possibly be done, pieces having heavy cores should be rough fettled before being placed in the furnace. The annealing will then be more efficiently and expeditiously carried out.

Generally, if arrangements are made which will admit of castings being cooled off quickly through the critical

FIG. 8.   SUITABLE DESIGN FOR TEST PIECE

range without risk of distortion, setting up of stresses, etc., through currents of cold air impinging on one part of a casting, or other causes, an increase in the tensile strength without decrease in the elongation can be looked for and, owing to the closer structure, better results from bend and shock tests obtained.

Many cases have been noted where mild qualities of steel, as cast, have given practically the same tensile strength and elongation as after annealing—for instance, a breaking strain of about 60,000 lb. per sq.in. with 28 to 30 per cent elongation in 2 in. Untreated samples fail, however, to give anything approaching satisfactory bend tests.

SHOCK TEST

It is possible that manufacturers of high-quality castings may soon consider that some form of shock test might by no means be against their interests if lower grade material, less suitable for the purpose required and supplied at a cheaper rate, be in this way eliminated from competition. The importance of the annealing or heat treatment of steel castings has been specially mentioned in papers read at various times, and a study of these is well worth the time so spent by anyone responsible for the production of steel castings, as are also papers which have recently been read on steel ingots, the problems requiring solution being closely allied.

The aim of every maker should be to produce castings absolutely, not commercially, free from defects, and the engineer should be willing to give earnest consideration to any reasonable modifications which may be suggested by men of experience. By close co-operation, steel castings might be produced which could be used with the same confidence as is extended to forgings when it is borne in mind that practically the same structure in the steel can be obtained by correct heat treatment as by work done on the steel during the process of manufacture.
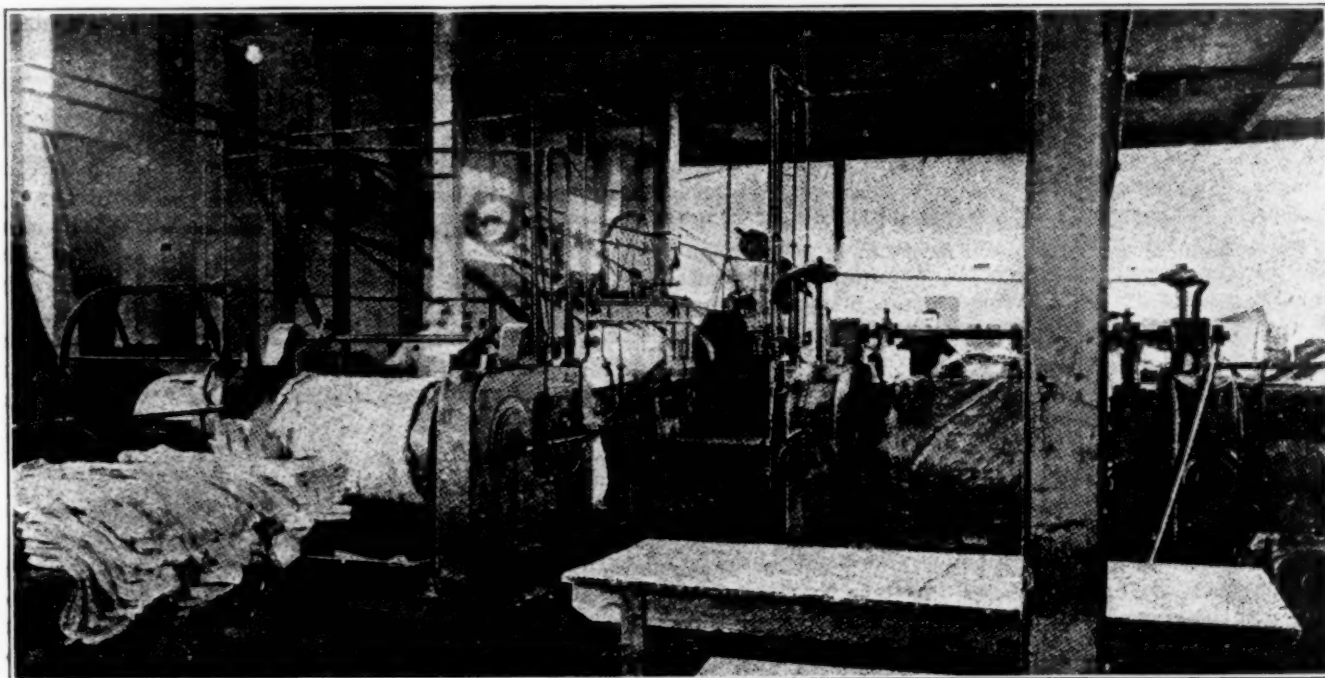
ROLLING OF CELLULOSE-ACETATE-BASE CELLULOIDS

Manufacture of Cellulose Acetate*

Generalities on Cellulose Acetates—Esterification—Operating Conditions—Industrial Manufacture by the Acetylation of a Modified or Natural Cellulose With or Without Solution of the Cellulose in the Esterifying Bath

By MAURICE DESCHIENS

THE chemistry of cellulose acetate has been greatly developed during the last few years. This product finds now extensive use in a great number of industries, especially in aëronautics, films, non-flammable celluloids, imitation coral, amber, shells, ivory, artificial flowers, non-breakable and flexible window glass, transparent sacks, electric insulators, artificial silk, etc.

GENERALTIES ON CELLULOSE ACETATE

The composition of cellulose might be given as $(C_6H_{10}O_5)_x$ or, if x is assumed to be 12, $C_{72}H_{120}O_{60}$. The simplified formula may be written as $C_6H_{10}O_5$.

The three best-known acetylated derivatives of cellulose by acetic acid and anhydride in the presence of appropriate catalysts are

$C_6H_9O_4(OCOCH_3)$ = mono-acetate

$C_6H_8O_3(OCOCH_3)_2$ = di-acetate

$C_6H_7O_2(OCOCH_3)_3$ = tri-acetate or normal acetate

The cellulose acetylation reaction does not consist in a simple substitution of the alcohol radical OH by an acid radical, but is in reality very complex due to the fact that partial hydration of the cellulose may take place during the normal acetylation process, or coincident with or following the acetylation, with the result that there is an undetermined number of inter-

*Abstracted and translated from *Chimie et Industrie*, May, 1920, pp. 591-607.

mediate products of hydrocellulose acetates as proved in the determination of viscosities, solubilities and saponification indices.

From the technical and industrial point of view the tri-acetate is the only one of interest and the acetylation methods are for the production of this acetate. Industrially it is difficult to obtain the tri-acetate as the final product, as this is mixed with lower acetates, especially the di-acetate $C_6H_8O_3(OCOCH_3)_2$ and compounds of partial hydrolysis (hydrocellulose acetate and hydrocellulose). This is due to the complexity of the esterifying bath, which contains sometimes cellulose, oxycellulose (action of oxidizing agents on the cellulose), hydro-cellulose (hydrolysis of cellulose) and acetic esters of cellulose. When sulphuric acid or sulphates are used as catalysts, sulphuric esters are also present (action of sulphuric acid) and acetosulphuric compounds (combined action of acetic and sulphuric acids), all in the normal and partially hydrated forms. Besides, there may also be present one or more series of cellulose decomposition products in different states of hydrolysis and esterification.

From the examination of industrial acetates of different origins it is possible to conclude that even the acetates prepared in the same plants by the same processes have variable solubilities and viscosities and no relation can be established between the contents in acetyl of these acetates and their physical and

chemical properties. It can be said, though, that the presence of sulphuric acid or sulphates in the cellulose acetates produces instability and exerts an appreciable influence on the solubility.

It often occurs that cellulose acetates which analytically are identical have very different physical properties.

A series of analyses has shown that: The percentage of the cellulose acetate which is insoluble in acetone varied from 3 to 0.2 per cent. The viscosity of a 6 per cent solution of cellulose acetate in acetone at 15 deg. C. gave figures varying from 90 to 5, the viscosity of 30 deg. Bé. glycerine being 100. The free acidity expressed as per cent CH_3COOH varied between 0.01 and 1; ash between 0.8 and 0.13 per cent.

The acetates containing the higher acidity, the greater quantity of ash and of insolubles are the most unstable to heat, decomposition starting at 176 deg. C., whereas for normal acetates decomposition starts at 210 to 215 deg. C., which shows that the industrial product is a mixture of di- and tri-acetate. That this is so can be proved by determining the acetyl percentage by the Barthelemy method of saponification.

The theoretical percentages of CH_3CO are: for di-acetate 34.96 and for tri-acetate 44.79.

A commercial acetate from the Usines du Rhône having the following properties was found to contain 43.08 per cent CH_3CO:

Viscosity at 15 deg. C. (30 deg. Bé, glycerine = 100)	16.5
Insolubles in acetone at 15 deg. C.	0.2 per cent
Free acetic acid	0.005 per cent
Ash	0.18 per cent
Moisture	5.3 per cent
Decomposition starting at	218 deg. C.
Total decomposition at	224 deg. C.

Industrially it is practically impossible to avoid the mixture, because usually only minimum amounts of acetic anhydride are used in the reaction with cellulose.

There is no acetate perfectly pure. The acetic esters being non-crystallizable, the law of mass action (the reciprocal reactions of two substances depend not only on their affinity constants but also on their relative concentration) cannot be applied to the system of the mixture of acid and cellulose acetate due to the total absence of homogeneity. This law applies only when all of the cellulose acetate is in solution.

Cellulose acetates decompose when submitted to vaporization or distillation.

Commercial tri-acetates when heated change aspect slowly between 175 and 220 deg. C. and carbonize between 188 and 270 deg. C.

ESTERIFICATION

Cellulose tri-acetate is obtained by direct acetylation of dry cellulose with acetic anhydride and acid, but as these organic acids, although strong, do not have hydrolyzing power, the hydrolysis is started by introducing in the mixture traces of inorganic acids (H_2SO_4 or H_3PO_4) or compounds giving inorganic acids (zinc chloride, ammonium persulphate, acid potassium sulphate, methylamine sulphate, copper sulphate). It is advisable that the formation of the esters shall be slow, because an energetic hydrolysis has a strong influence on the molecule of cellulose to be esterified.

The acetylation is a bimolecular reaction, expressed by the following equilibrium:

$$C_6H_{10}O_5 + CH_3COOH \rightleftharpoons C_6H_7O_2(OCOCH_3)_3 + 3H_2O$$
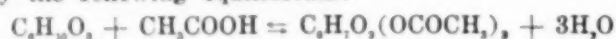
The acetylation is improved by raising the tempera-

ture carefully to a degree which is determined according to the catalyzer used. Thus, for $ZnCl_2$, $KHSO_4$ and ammonium persulphate 80 deg. C. is the most favorable temperature. To absorb the water formed during the reaction and to eliminate it from the esterification it is necessary to use energetic dehydrating agents such as H_2SO_4, H_3PO_4, or $ZnCl_2$.

Equilibrium is reached when the acetylated cellulose is dissolved or nearly dissolved. The mixture is heterogeneous when the cotton fibers are not appreciably changed in appearance; it is homogeneous when the cellulose passes into solution in the acetylating mixture.

In the manufacture of nitrocellulose the esterification is energetic and perfect because nitric acid is a vigorous esterification agent; in the case of cellulose acetates the esterification is slower and the destructive action of the acids on the ester during the acetylation is more profound. In the case of the nitrates, these are insoluble in the nitrating mixture and hence no destructive action takes place, whereas the acetates pass in solution, the acetic esters being soluble in the acetic acid and anhydride. Any process by which this solution could be stopped would be of great technical and economic importance, because it would permit a reduction of the quantity of acetic anhydride necessary for the production of a unit of acetylated cellulose and would give a more regular acetylation, without secondary reactions.

L. Ledebur and many other authors propose to add to the acetylating bath a sufficient quantity of carbon tetrachloride, cellulose acetate not being soluble in a mixture of acetic anhydride, acetic acid and carbon tetrachloride. This process is interesting in that the boiling point of carbon tetrachloride (83 to 84 deg. C.) is lower than that of the acetic anhydride (138 deg. C.) and acetic acid (119 deg. C.) and by fractional distillation the carbon tetrachloride can be recovered.

In an industrial acetylation the carbon tetrachloride is added at the end of the esterification operation to precipitate the cellulose acetate. The precipitate is separated by filtration, centrifuging and drying.

OPERATING CONDITIONS

The main points to be considered in the manufacture of cellulose acetates are:

(1) A careful selection of the materials used. The cellulose, acetic acid and acetic anhydride are to be analyzed before used, so that when needed their proportions may be logically modified to give as uniform as possible final commercial products.

(2) Slow and regular acetylation with a thorough temperature control. It has been proved that the variations in viscosity are a function of the acetylation temperature. For a given process an increase in temperature results in cellulose compounds of lower molecular weight, greater viscosity and lower solubility.

(3) Hydrolysis and ripening should be as uniform as possible and under constant supervision with frequent sampling. The samples should be analyzed for solubility (the solubility in acetone being the measure of acetylation for the tri-acetate), plasticity (the plasticity in warm chloroform being also the measure of acetylation for the tri-acetate). It is also a good plan to make microscopic examinations.

It has been stated previously that cellulose acetates even when manufactured by the same process and similar analytically may possess very different qualities

These variations may be due to the status of hydrolysis during the treatment of the cellulose, to not sufficiently well-controlled esterification, hydrolysis or ripening, or to defective precipitation and washing.

Samples of cellulose tri-acetate to be considered good have to be very soluble, have a very low percentage of H_2SO_4 and resist the heat test. The following table gives the analysis of the most commonly used tri-acetates:

	Moisture	Ash	Viscosity*	% Free Acetic Acid	% H_2SO_4	Temp. at Decomposition
Acetate H. Dreyfus of Basel	5.97	0.32	18 9	0.005	0.34	178
Acetate H. Dreyfus of Basel	3.95	0.45	27	0.006	0.53	173
English acetate............	4.94	0.42	30.6	0.006	0.90	170
British Cellulose Co.......	5.22	0.41	38.2	0.068	0.24	164
Usines du Rhone..........	4.40	0.40	11.3	0.004	0.21	218
Usines du Rhone..........	4.96	0.16	10.0	0.01	0.12	226

* Viscosity at 15 deg. C. of 6 g. in 100 g. acetone. (Viscosity of 30 deg. Bé. glycerine = 100.)

The presence of sulphuric acid in the tri-acetates is very harmful; it diminishes their solubility because it tends to transform them into di- and mono-acetylated derivatives which are insoluble in the usual tri-acetate solvents. This transformation takes place with the production of free acetic acid, so that the presence of too great a quantity of free acetic acid indicates unfavorable conditions.

METHODS USED FOR THE ACETYLATION OF CELLULOSE BY ACETIC ACID AND ANHYDRIDE

The method of direct acetylation of cellulose by acetic acid and anhydride in the presence of acetyl chloride is no longer used. The two methods now used are:

I. Acetylation of a modified cellulose (hydrocellulose, oxycellulose, viscose).

II. Acetylation of natural cellulose (cotton, paper, etc.).

In these two methods the two distinctive cases to be considered are whether the cellulose is or is not dissolved in the esterifying bath.

ACETYLATION OF A MODIFIED CELLULOSE

The Badische Anilin und Soda Fabrik has taken out a series of patents on the hydrolysis of the cellulose by saturation with dilute sulphuric acid (catalyzer) and the acetylation of the hydrolyzed mass separated from the acidulated water. The two cases to be considered are:

(A) Acetylation With Solution in the Esterifying Bath.—100 parts cotton to be acetylated are saturated with a 4 to 5 per cent solution of sulphuric acid for sufficient time, then the cellulose is pressed until it contains twenty parts of the diluted acid. The hydrolyzed cotton is loosened and introduced in a mixture of 400 parts acetic anhydride and 400 parts of acetic acid. The reaction is exothermic and the temperature is to be kept around 40 deg. C. The acetylation is complete when the cellulose is entirely dissolved; the cellulosic ester is then precipitated by water, washed and dried.

(B) Acetylation Without Solution in the Esterifying Bath.—100 parts are saturated with a 60 per cent solution of sulphuric acid and pressed until the cotton retains only 10 parts of the acid solution. The resulting hydrolyzed cellulose is placed in contact with 300 parts of acetic anhydride and 1,100 parts benzene (precipitant for cellulose acetate). The acetylation lasts twelve hours, then the temperature is raised and

maintained at 60 to 65 deg. C. on a water bath until a sample indicates an acetate soluble in warm chloroform. The cellulose acetate which has not been dissolved is pressed, neutralized with Na_2CO_3 solution, washed and dried. By this method the cellulose retains the texture and form of the initial fiber.

A French patent (316,500) proposes the use of ortho-, pyro- or meta-phosphoric acids or P_2O_5 as catalyzers for the acetylation of a hydrocellulose or oxycellulose (100 parts) with 400 parts of acetic anhydride containing 1 per cent of the catalyzers mentioned, the temperature being maintained at 50 to 60 deg. C.

The acetates obtained by this process are not very resistant, and it is to be remarked that the less the initial cellulose material has been hydrolized the better the cellulose acetate produced.

ACETYLATION OF NATURAL CELLULOSE

The modern method for the preparation of the cellulose acetate is by the acetylation of natural cellulose based on the treatment of cleaned and dried cellulose by acetic acid and anhydride in the presence of a catalyzer. The catalyzers used are H_2SO_4, $KHSO_4$, $CuSO_4$, methylamine sulphate, ammonium persulphate, $ZnCl_2$, etc., the most commonly used being sulphuric acid. Here also, as in the case of the treatment of a modified cellulose, the acetylation is made with or without solution of the cellulose in the esterifying bath.

(A) Acetylation With Solution in the Esterifying Bath.—This method is best outlined by giving the description of the reactions taking place according to
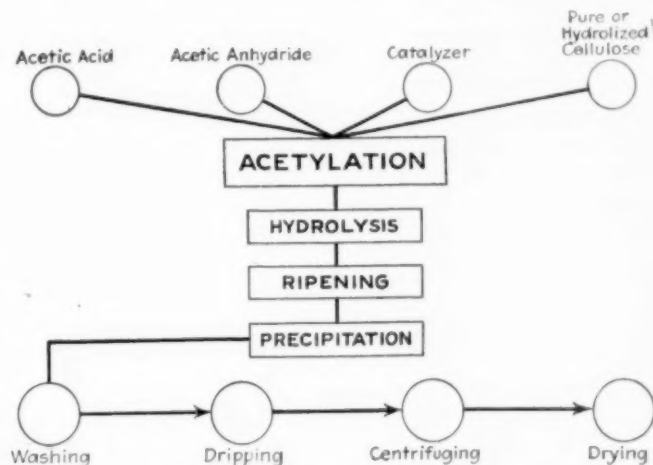
FIG. 1. FLOW SHEET OF THE MANUFACTURE OF CELLULOSE ACETATE

the principles forming the basis of G. W. Miles' American patent 838,350 (1906). The entire operation consists of five phases, the temperature varying with the catalyzer used.

First Phase: Acetylation. Dried cellulose (100 g.) is introduced in a mixture of pure acetic anhydride (270 to 310 g.) and glacial acetic acid (390 to 410 g.), to which is added the catalyzer consisting of 66 deg. Bé. sulphuric acid (3 to 5 c.c.). The whole is well mixed and triturated in rocking mixers having two helicoidal blades. The mixer is jacketed so as to permit of temperature control of its contents; the inner wall is of bronze, aluminum or enamel. Capacity of mixer 300 to 600 l. The reaction is exothermic. The temperature is to be maintained at 40 deg. C. until the

mass becomes of homogeneous appearance, when the temperature may be allowed to reach 50 to 65 deg. C. When the temperature starts to drop the mass is heated on a water bath and kept at about 50 deg. until the cellulose is entirely dissolved. This requires from thirty-six to forty-eight hours and even longer. The end of this phase is reached when a sample precipitated by water is soluble in cold cholorform and insoluble in acetone.

Second Phase: Hydrolysis. A mixture of 60 to 65 c.c. water and 60 c.c. acetic acid per 100 g. cellulose is added slowly to the esterifying bath by continuous agitation. During this phase of the operation there must not be any precipitation of cellulose acetate.

Third Phase: Ripening. The mass from the mixer is transferred to similar mixers but of greater capacity and allowed to ripen at 40 to 50 deg. C. for twelve to sixteen hours. During this time hydrolysis takes place uniformly and slowly and the cellulose acetate which was insoluble in acetone becomes gradually soluble while the solubility in cold chloroform diminishes. This ripening results in a greater and more complete division of the cellulose acetate molecule, as can be seen by examining samples at different stages, the product becoming more and more a tri-acetate soluble in acetone, more divided and less granular.

Frequent samples for the determination of viscosity and solubility will indicate the point when the cellulose acetate is of the required quality. The ripening phase is to be guided by the following characteristics:

A product soluble in cold chloroform and insoluble in acetone indicates that the ripening is not complete.

A product insoluble in cold chloroform, plastic in warm chloroform and soluble in acetone indicates that the ripening is complete and the tri-acetate of cellulose is of the desired quality.

If this stage of ripening is passed the product becomes a complex mixture of hydrocellulose acetates which after precipitation is in the form of powder whose solubility and qualities are very variable. If the ripening is carried still further the product obtained is a biose (cellobiose, $C_{12}H_{22}O_{11}$).

Fourth Phase: Precipitation. The acetylated mass is transferred to precipitation vats and precipitated with an excess of cold water to which is added an alkaline carbonate sufficient to neutralize the sulphuric acid used. The whole is stirred mechanically. The acetate is precipitated as a white flocculent mass which is to be washed and neutralized as perfectly and as fast as possible so as to avoid the hydrolyzing action of the sulphuric acid which would give acetates of lower molecular weights, less resistant and susceptible to decomposition during storing.

Fifth Phase: Drying. The neutralized and washed cellulose acetate is placed in drying chambers and maintained at a temperature of 20 to 25 deg. C.

The theoretical efficiency is seldom realized, but with carefully controlled acetylation, hydrolysis and ripening stages, the industrial efficiency of the reaction

$$C_6H_{10}O_5 + 3CH_3COOH \leftrightharpoons C_6H_7O_2(OCOCH_3)_3 + 3H_2O$$
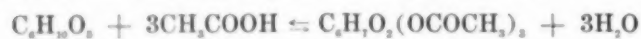
reaches 83 per cent.

In all the acetylation methods these five phases of the entire operation are to be considered. The temperature and duration of each phase vary with the catalyzer used. Thus: With ZnCl, the acetylation, hydrolysis and ripening are performed at 65 to 70 deg. C., with nitrosyl sulphate at 70 deg. C., with ammonium bisulphate at 50 deg. C., with methylamine sulphate or aniline sulphate at 30 to 60 deg. C. and with potassium bisulphate at 80 deg. C.

THE NAAMLOOZE VENNOOTSCHAP CO.'S PROCESS FOR THE PREPARATION OF CELLULOSE TRI-ACETATE

A new method for the preparation of cellulose tri-acetate is that of the Naamlooze Vennootschap Fabriek van Chemische Producten Co. of Holland (French patent 494,832 of June 10, 1919). The principle is to submit the cellulose to a preliminary treatment by which the penetration of the catalyzer into the cellulose fibers is greatly facilitated.

This method can be realized in the following two ways:

1. By the use of glacial acetic acid.

2. By the use of weak acetic anhydride.

(1) *Use of glacial acetic acid.* (a) *Preparatory treatment.* 100 g. cellulose is impregnated with 500 c.c. of glacial acetic acid and 5 g. of 62 to 66 deg. Bé. sulphuric acid. Let stand for twenty hours at 15 to 20 deg. C. (b) *Acetylation.* Add 500 g. of 80 per cent acetic anhydride, cool to maintain the temperature at 40 deg. C. until a clear solution is obtained. (c) *Hydrolysis and ripening.* After a few hours add 40 to 60 c.c. of 10 per cent sulphuric acid and let ripen for twenty-four hours at 35 deg. C. (d) *Precipitation and drying.* The precipitation is realized by the use of an excess of cold water and the precipitate washed and dried.

(2) *Use of weak acetic anhydride.* When it is desired to use weaker acetic anhydride the operations are as follows:

(a) *Preparatory treatment.* 30 g. of cellulose is impregnated with 300 g. of a mixture of 40 per cent acetic anhydride and 60 per cent acetic acid for sixteen hours at 16 deg. C. (b) *Acetylation.* Raise the temperature to 35 deg. C. with constant stirring until a clear homogeneous mass is obtained. (c) *Hydrolysis and ripening.* Add 18 to 20 c.c. of 10 per cent sulphuric acid solution and let digest for twenty-four hours at 35 deg. C. (d) *Precipitation, washing, drying as in the previous methods.*

(B) *Acetylation Without Solution in the Esterifying Bath.*—A typical example of this method is that forming the subject of Harry S. Mork's American patent 854,374 (1907). The operation is as follows: (a) *Preparatory treatment.* Treat 100 g. of cotton with a mixture of 400 g. of pure acetic acid and 20 g. benzene sulphonic acid for a few hours; the mass is pressed until it contains half of the original liquid and ripened for twelve hours at 15 to 20 deg. C. (b) *Acetylation.* The wet cellulose is esterified by immersion in a bath containing 300 g. of acetic anhydride and 1,200 g. benzol. (c). *Ripening.* The mass is maintained for about eighteen hours at 15 to 20 deg. C. until a sample indicates a product of the desired solubility. (d) *Precipitation, washing and drying as in the previous methods.* The Société Debauge et Cie. (French patent 450,886—1915) uses a similar process with benzene, toluene or carbon tetrachloride as precipitants for the cellulose acetate.

(An article on the Properties and Industrial Uses of Cellulose Acetate will be published in a subsequent issue.)

Failures From Contraction of Welded Straight Piping Solved by Using Welded Bent Piping

An unusual contraction problem arose recently in connection with the pipe welding on fifty-four large gasoline condensers for the Texas Oil Co. Each condenser consists of four large forge-welded drums and seventy lengths of extra heavy 2-in. pipe. The drums are open at one end and flanged so that they may be bolted or riveted together after the pipes are welded in.

The pipe welding is being done by the Oxweld Acetylene Co. at the welding shop of that company's Newark plant. The original plan called for straight piping in line of center between each lateral pair of drums and bent or bowed piping to connect the sides. As the distance between the drums had to be exact to meet the foundation specifications and to insure coincidence of the flanges and bolt or rivet holes of one set

APPLICATION OF WELDED BENT PIPING

of drums with the corresponding points in its mates, the importance of properly handling the contraction problem is at once apparent.

Oxweld engineers recommended the substitution of bent piping for the straight piping noted. The theory as to contraction control was tested on both the straight and the bent pipe. Accordingly a heavy cast-iron jig was made, to which the drums were made fast in the proper position with heavy bolts. The contraction when the straight pipe was used was so powerful that the bolts were sheared off by the pull on the drum, the contractions amounting to several inches. When the bent pipe was used instead of the straight pipe this did not occur, the bent pipe accommodating itself to the contraction so completely that when the drums were removed from the jig they were found to be in correct position, fitting perfectly with the mating pairs.

The application of the bent piping is clearly shown in the accompanying photograph. After the welding, the condensers are tested to a hydraulic pressure of 500 lb. per sq.in. In one of these tests a 3-in. cast-iron cap bolted to one of the drums gave way, but the pipe welds in every instance stood the test without a break or a leak appearing, clearly demonstrating the remarkable strength of the oxy-acetylene welds to resist unusual pressure strains. There are thirty-five pipe welds in each drum and 140 in each complete condenser, a total of 7,560 welds in the fifty-four condensers.

The fifty-four condensers will be used in the distillation plant of the Texas Oil Co. for recovering gasoline from natural gas and crude oil.

Synopsis of Recent Chemical & Metallurgical Literature

The Sugar Situation in France.—The sugar situation in Europe has suffered very much during the war, as can be seen from the following data taken from a study by P. NOTTIN on the French sugar industry before and after the war. (*Bulletin* de la Société d'Encouragement pour l'Industrie Nationale, vol. 132, 1920, pp. 103-108). Thus the European production of 8,179,013 tons of sugar for the fiscal year 1913-14 was reduced to 3,642,-664 tons for the fiscal year 1918-19. This decrease in production was more accentuated in France and Belgium and the present conditions in these two countries are far worse than in the other sugar-producing countries, because the greater part of the French and Belgian sugar refineries have been wantonly destroyed.

The following table shows the status of the French sugar industry during the war:

Fiscal Year	Sugar Beet Acreage Cultivated	Number of Sugar Plants In Operation	Amount of Sugar Produced, Tons
1913-14	515,000	206	717,400
1914-15	331,000	69	302,960
1915-16	186,800	64	135,899
1916-17	201,000	65	185,435
1917-18	187,000	61	200,265
1918-19	169,200	51	110,096

Of the 206 sugar refineries in operation in 1913-14, 145 have been wrecked. Only fifteen of these plants can be repaired; the remaining 130 have had all the machinery and apparatus completely destroyed beyond repair and in ninety plants even the buildings have been demolished. In the four main French sugar-producing departments—Aisne, Nord, Somme and Pas-de-Calais—the number of refineries and their power during 1914 and 1919-1920 were:

Department	1914		1919-1920	
	Number of Plants in Operation	Power	Number of Plants in Operation	Power
Aisne	47	19,920	1	200
Nord	38	19,135	1	325
Somme	34	17,250	3	4,400
Pas-de-Calais	25	12,260	6	5,430

Of the 700,000 tons of sugar constituting the average French yearly consumption, the maximum which can now be produced is about 275,000 tons, to which may be added a maximum of 110,000 tons of cane sugar from the French colonies (Guadelupe and Martinique). Although a sugar-exporting country in 1913, France has now to import about half of its needed sugar. It will take years before the French sugar industry will be able to resume its former status.

In spite of European conditions, however, the world's cane sugar industry has flourished during the war. Thus the cane sugar production has increased from 9,821,413 tons in 1913-14 to 12,009,866 tons during 1918-19. Before the war cane sugar constituted 52.6 per cent of the total world production; in 1918-19 this figure was increased to 73.4 per cent.

The beet sugar industry has grown during the last few years in America; the same can be said of Cuba for the same sugar.

The following table summarizes the status of the sugar industry in the main sugar-producing countries:

| | — Period 1911-1914 — | | — Period 1918-1919 — | |
	Production, Tons	Percentage of the World's Production	Production, Tons	Percentage of the World's Production
United States and dependencies	4,435,000	24 3	6,020,300	36.8
Great Britain and colonies	3,280,000	18 0	3,263,300	19.9
Holland and colonies	1,582,000	8 6	1,846,600	11.2
Germany	2,365,000	13 0	1,412,000	8 6
Russia	1,812,000	9 8	700,000	4.2
Austria-Hungary (Czechoslovakia)	1,579,000	8 6	700,000	4.2
Japan	229,000	1 2	375,000	2 2
Brasil	215,000	1 1	260,000	1.5
Peru	168,000	0 9	250,000	1 5
Argentina	219,000	1 2	240,000	1.4
France and colonies	863,000	4 7	219,800	1.3

It can be seen that the United States and its dependencies produce more than a third of the total world production, Great Britain with its colonies more than one-fifth, whereas France with its colonies has fallen from the seventh to the eleventh rank.

Catalytic Action of Copper Salts on the Oxidation of Ferrous Compounds.

—Iron salts act as reducing or oxidizing agents according to whether the reaction takes place in an alkaline or acid medium. Thus ferrous salts precipitate cuprous oxide from alkaline solutions of copper, whereas ferric salts in acid solutions dissolve the cuprous oxide and become ferrous. L. MAQUENNE and E. DEMOUSSY have conducted a series of experiments to determine the action of copper salts on the oxidation of ferrous salts and presented the results of their work before the French Academy of Sciences (*Comptes rendus*, July 12, 1920, pp. 65-69).

Working on a solution containing 1 g. crystallized ferrous sulphate per liter and varying amounts of sodium acetate with or without the addition of 2 mg. anhydrous copper sulphate per liter, the quantities of superoxidized iron in one dl. of the solution after one and two days standing are given in the following table:

Sodium acetate mg. per dl. of solution		100	200	500
Superoxidized iron mg. per 24 hr.	without copper	2 4	3 9	6.3
	with copper	5 0	6 5	7.9
Superoxidized iron mg. per 48 hr.	without copper	3 1	5 3	7 7
	with copper	5 9	7 9	8.9

It is seen that in each case copper favors the oxidation of the iron, the more so the less the acetate content of the solution. Ferrous acetate is much more alterable than the sulphate. An addition of a single drop of acetic acid retards notably the reaction, due to the fact that the hydrolysis coefficient of the ferrous acetate is lowered. With a stronger acid the effect is the same but much more intensified.

The action of an alkali phosphate is similar to that of the alkali acetate and with even better results. Thus in a solution containing 32 mg. of ferrous sulphate with 80 and 320 mg. of acid potassium phosphate (KH_2PO_4) per 100 c.c. of solution without or with 0.4 mg. copper sulphate, the quantities of oxidized iron after one, two and three days' exposure in the air are given in the following table:

Acid potassium phosphate mg. per 100 c.c.		80	320
Superoxidized iron mg. per 24 hr.	without copper	0 5	1.2
	with copper	1 2	4.3
Superoxidized iron mg. per 48 hr.	without copper	0 8	1 5
	with copper	2 7	5.0
Superoxidized iron mg. per 72 hr.	without copper	0 8	1 5
	with copper	3 3	5 5

An excess of phosphate up to twenty-five times the weight of the ferrous sulphate used gives similar results. The addition of 0.2 mg. copper sulphate per 100 c.c. of a solution containing 40 mg. iron sulphate and 1 g. monopotassium phosphate is sufficient to double the quantity of the iron oxidized per 24 hr. An excess of acid even when small hinders the reaction as shown by the following results with a solution containing 40 mg. iron sulphate, 200 mg. monopotassium phosphate and 0.2 mg. copper sulphate per 100 c.c. to which is added varying amounts of sulphuric acid:

	Iron Oxidized in 24 Hr.
Without excess of acid	3 6 mg.
With 1 mg. H_2SO_4	3 3
With 2 mg. H_2SO_4	2 1
With 5 mg. H_2SO_4	1.4

It is seen that the retarding action of sulphuric acid is already appreciable with 1: 100,000 dilution.

Under normal conditions—i.e., without an excess of acid—the rapidity of the reaction depends on the quantity of phosphate and copper sulphate used. Thus in a solution containing per liter 400 mg. iron sulphate (exactly 79.1 mg. Fe) 2 g. phosphate and 0.2 or 0.8 mg. of copper sulphate the following results were obtained:

	Iron Oxidized Mg. After						
	1 Day	2 Days	3 Days	5 Days	7 Days	16 Days	25 Days
Without copper	8 6	12 0	15 5	17 2	18 9	25 8	29 2
With 0 2 mg. $CuSO_4$	20 6	25 8	31 0	32 7	36 1	49 9	56.8
With 0 8 mg. $CuSO_4$	36 1	44 7	49 9	55 0	60 0	68 0	74 0

After more than twenty-five days with greater amounts of copper sulphate the efficiency of the oxidation may reach 0.93 per cent of the initial iron, whereas when no copper sulphate is used the maximum oxidation efficiency is only 37 per cent of the initial iron.

The action of the copper is manifested even with a 1: 100,000,000 dilution, which is of the same order as that for diastases and coenzymes producing similar actions. The action of the copper is also influenced by the temperature.

There exists thus a profound analogy in the action of copper and the diastatic action, and this might lead to a better understanding of the action of copper on living organisms.

Manganese under similar conditions does not react. In vacuum, with copper, the same as with the oxydases, no reaction takes place.

Their conclusions are:

1. Copper salts exert on ferrous compounds a catalytic action the effect of which is to facilitate their oxidation in the air.

2. This activating action which is already appreciable with extremely diluted solutions and sensitive to the slightest changes in the composition of the reacting medium is somewhat specific and consequently can be compared to that of the diastases from which it differs only in that the reactions take place in the absence of any organic matter. (Solutions of alkaline sulphates are also oxidized rapidly in the air when even traces of copper are present. This is one of the causes of alteration of the developing baths in photography.)

3. The effect is manifested in sufficiently diluted solution to warrant the statement that the electrolytic dissociation of the ferrous and cupric salts which takes place is complete and in a direct ratio with their hydrolytic dissociation.

Recent Chemical & Metallurgical Patents

British Patents

Process for Sterilizing Food.—A process for sterilizing food, such as fruit and vegetables and other organic substances, such as starch and gelatine, but especially applicable to milk, consists in heating the substance to be treated while it is exposed to a pressure of one atmosphere or over of some appropriate gas. For milk, air or nitrogen may be used, but pure oxygen is not suitable. It is stated that milk treated by this method at temperatures between 70 and 98 deg. C. lasts less well than milk that has been treated at temperatures either just below 70 or above 98 deg. C., the process last described giving the greatest durability. To cause the milk to retain its odor and taste, rapid oscillations of temperature are produced during the process, either by forcing comparatively cold gas through the highly heated milk, or highly heated gas through comparatively cold milk, the pressure being maintained constant throughout the process by a loaded relief valve. (Br. Pat. 142,169—1919. R. PAPE, Busum, Holland, June 30, 1920.)

Apparatus for Catalytic Synthesis of Ammonia.—In an apparatus for the catalytic synthesis of ammonia at pressures exceeding 500 atmospheres the removal of the ammonia from the product of the reaction is effected by means of a series of tubes each entering the cata-

lyzer tubes and connected to a cooled receiver, the gases freed from ammonia passing back to the catalyzer tube by a tube surrounding the exit tube, this circulation of gas being induced by the difference in density between the mixture containing ammonia and the mixture freed from ammonia. The apparatus illustrated consists of an outer steel tube T^1 and an inner metal tube T^2 separated by a layer of heat-insulating material; a shorter inner tube T^3 surrounded by an electric heating-spiral S extends as far as the plug M, this tube T^3 and the portion of tube T^2 beyond the plug M being filled with the catalyst. The reacting gases enter by the pipe K and pass first through the annular space surrounding the tube T^3, thereby being heated to the reaction temperature (500-700 deg. C.) and then enter the mass of catalyst. The reaction gases are withdrawn by means of a series of pipes t^1, each of which penetrates into the catalyst and is connected to a cooled receiver C in which the ammonia condenses, the residual gas returning to the catalyst tube by pipes t surrounding the pipes t^1;
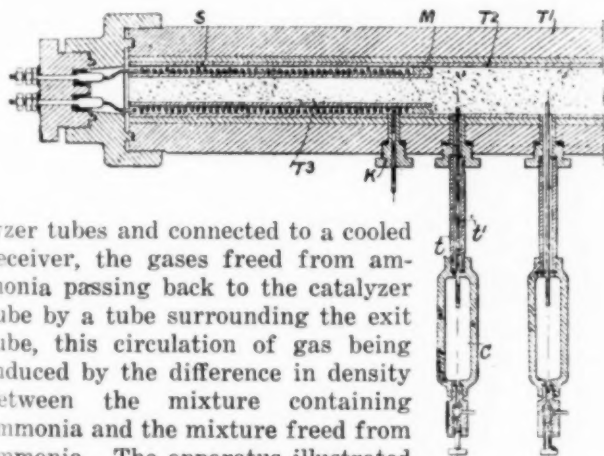
the pipes t are lagged with heat-insulating material. In a modified construction, the gases enter the catalytic apparatus through a central tube passing through the whole mass of catalyst, the arrangement for withdrawing the ammonia being the same as that described above. (Br. Pat. 142,150—1919. L'AIR LIQUIDE, SOC. ANON, POUR L'EXPLOITATION DES PROCÉDÉS G. CLAUDE, Paris, June 30, 1920.)

Calcium Cyanamide.—In the production of cyanamide from calcium carbide and nitrogen the nitrogen is forced under pressure upward through a furnace
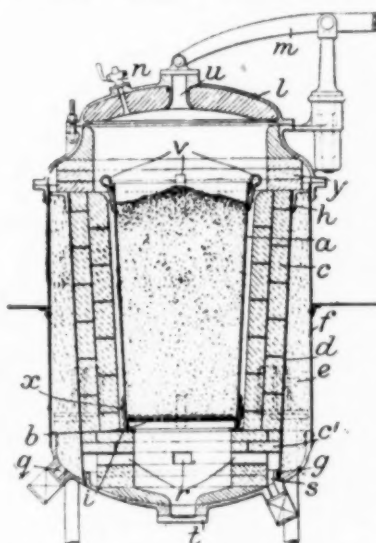
jacket packed with fibrous material such as asbestos, and then downward through the carbide in the furnace. The reaction is started by a heat-absorbing lining to the furnace which has been heated by a previous operation, or by electric resistances in the furnace lining, or by an aluminothermic or similar mixture introduced in a cartridge or container. The apparatus described consists of an outer shell f, an inner airtight shell d, asbestos or like packing e, between them, brickwork such as magnesia bricks c, c^1, and a crucible a. The shell d is secured at the top to an angle-iron h and at the bottom by an asbestos joint g. The crucible has a perforated bottom b upon which is placed a layer of asbestos and/or stout paper, which becomes carbonized; it is provided with lifting hooks v and centeringpieces x, and rests upon an annular asbestos packing i. The cover l is lifted by means of a lever m, a valve n being provided for releasing the pressure before lifting the lid. The reaction may be started in the first instance by burning straw inserted through opening u. Nitrogen is supplied by a pipe q, passes through the packing e between the shells d, f, thence through openings y in the brickwork and downwardly through the carbide in the crucible a, and passes through the bottom of the crucible and by passages r in the brickwork to an exit s. Dust is removed by an opening t. The separate crucible a may be dispensed with. Several such furnaces may be connected in series. (Br. Pat. 142,354—1919. A. DUCHEMIN, Paris, June 30, 1920.)

Treating Paraffine Wax to Obtain Fatty Acid.—Paraffine wax, while melted and at a temperature of 100-120 deg. C., is submitted to the action of a blast of air or oxygen over a long period, resulting in the formation of oleic and other fatty acids, resin acids, ceresin, spirits of resin and small quantities of alcohols and aldehydes. To prevent decomposition of the products, the process is stopped when a deep yellow color is produced, corresponding to a 70 per cent conversion of the paraffine wax. A catalyst, such as mercuric oxide, or paraffine wax, which has previously been subjected to the foregoing treatment, may be added. (Br. Pat. 142,507—1919. A. SCHMIDT, Troisdorf, near Cologne, Germany. July 7, 1920.)

American Patents

Complete specifications of any United States patent may be obtained by remitting 10c. to the Commissioner of Patents, Washington, D. C.

Treating Distiller's Slop.—Slops resulting from the production and separation of alcohol from black strap molasses contain certain carbohydrates which interfere with the satisfactory recovery of glycerine. HARRY P. BASSETT, of Cynthiana, Ky., has found that boiling with lime converts these carbohydrates into salts of the hydroxy-acids of the lactic acid series. Upon acidifying, the latter are decomposed with the formation of aldehydes and acids of the volatile fatty acid series. Of these, formic and acetic acids are present in substantial quantities and may be recovered by distillation. The solution is then treated with a mixture of ferrous and ferric sulphate and made alkaline, thus precipitating the basic iron salts of the fatty acids. The mixture is filtered and the filtrate evaporated until about two-thirds of the potassium salts present have separated out. The decanted liquid contains about 50 per cent glycerine, which may be recovered by steam distillation. (1,344,850 and 1,344,851; June 29, 1920.)

Vanillin.—Guaiacol and formaldehyde are mixed together in molecular proportions and diluted with methanol or ethyl alcohol, and an alcoholic solution of hydrochloric acid and of p-nitrosodimethylaniline in half molecular proportion is added. The mixture is heated for several hours on a water bath, gaseous hydrochloric acid being bubbled through continuously meanwhile.

The resulting products give an excellent yield of vanillin with p-amidodimethylaniline as a byproduct. The formed vanillin may be extracted by treating the product of the reaction after cooling with a dilute caustic soda solution, the alcohol is separated by distillation, and the p-amidodimethylaniline is then extracted with benzene or ether.

The remaining alkaline solution of vanillin is then acidified and extracted with benzene or ether, after which the solvent is distilled, the remaining crude vanillin being then distilled in vacuum and the vanillin, recrystallized in water, separates in crystals having a melting point of 81 deg. C.

The reaction gives a yield of 100 per cent of crude product with respect to the guaiacol used. (1,345,649; ANDRÉ WEISS, of Lyons, France, assignor to Société Chimique des Usines du Phone; July 6, 1920.)

Crystal Production.—A method for the production of large regular crystals, such as Rochelle salt, for use in scientific apparatus utilizing the piezo-electric effect is described by ROY W. MOORE, of Schenectady, N. Y. (1,347,350; assigned to General Electric Co.; July 20, 1920.)

Oxidizing Isoborneol to Camphor.—A process for oxidizing isoborneol to camphor which does not require the presence of a starter or catalyzer is outlined as follows by ROLAND L. ANDREAU, of Wilmington, Del.: A quantity of mixed nitric and sulphuric acids is made, containing the following proportions: 339 kg. of sulphuric acid, 66 deg. Bé., and 253 kg. of nitric acid, 26 deg. Bé., specific gravity 1.22. The mixed acid is introduced into a container, which may be provided with any desired type of stirring device. Thereupon about 1 kg. of isoborneol is added to the mixed acid. Only a small amount of the isoborneol is added in order to avoid having the reaction proceed too violently. If the reaction proceeds too violently the undesirable products,

such as resinous compounds and camphoric acid, will be formed, and the compounds will become subjected to such violent ebullition that they cannot be retained in the vessel. When the temperature has risen to above 40 deg. C., indicating that the reaction has begun, which will usually be after about 15 minutes, additional isoborneol is added gradually and with caution, taking care that the temperature of the mass remains between 35 deg. C. and 40 deg. C. during the reaction, continuing the addition until the entire amount of isoborneol added equals 154 kg. The supernatant liquid, which contains the camphor in the form of a loose addition compound with N_2O_3, is then decanted and run into water, where the camphor precipitates as a solid, and is then washed, centrifuged, dried and purified. In this way a substantially theoretical yield is obtained. (1,347,071; assigned to E. I. du Pont de Nemours & Co.; July 20, 1920.)

Cellulose Acetate.—Many attempts have been made to substitute the sulphuric acid used as contact, or condensing agent, in conjunction with glacial acetic acid and acetic anhydride in the manufacture of cellulose esters, on account of its high splitting action on cellulose. The halogen acetic acids have been suggested, but their action is very slow, even when employed in very large quantity. JOE O. ZDANOWICH, of London, England, has found that when these acids are formed in the acetylating mixture in the presence of cellulose their action is more energetic. Thus 20 g. of cellulose is added to a mixture of 60 c.c. of acetic anhydride and 110 c.c. of glacial acetic acid. While stirring, a current of chlorine gas is introduced, either at ordinary temperature or at 60 to 70 deg. C. After about two hours' time, either at this temperature or at the ordinary temperature, ten or twelve drops of sulphuric acid is introduced and the mixture is stirred until it changes into a clear, colorless, very viscous solution, which can be used for films, artificial silk, varnishes and the like, or can be precipitated, and treated and used in the usual way. (1,347,801; July 27, 1920.)

Electrolytic Pickling Process for Copper.—In order to avoid loss of ductility, copper is often worked while hot and in this state it oxidizes very readily. The removal of the oxide scale by pickling in sulphuric acid produces a solution of copper sulphate, the economical recovery of which presents a problem due to losses by leakage and accidents during operation. JOHN COULSON, of Wilkinsburg, Pa., proposes to make the copper body to be pickled the cathode in an electrolyte of dilute sulphuric acid, a lead-containing tank serving as the anode. The arrangement of the apparatus is such as to permit the articles being treated to be attached to the negative pole of the source of electric current before entering the electrolyte in order to prevent, from the outset, electrolytic action of the current upon the metallic copper. The copper oxide is, however, reduced to metallic copper by nascent hydrogen evolved from the electrolyte at the cathode. This process reduces the oxide very rapidly. In order to recover, from the electrolyte, the copper which is present in the form of copper sulphate, he provides a third or auxiliary electrode which may also be electrically connected to the negative terminal of the source of electrical energy. Copper from the electrolyte is deposited upon this auxiliary electrode and is thus recovered. (1,347,897; assigned to Westinghouse Electric & Mfg. Co.; July 27, 1920.)

Current Events
in the Chemical and Metallurgical Industries

Association of Iron and Steel Electrical Engineers

Following is the program for the fourteenth annual convention of the Association of Iron and Steel Electrical Engineers, to be held at the Hotel Pennsylvania, New York, Sept. 20 to 24:

MONDAY, SEPT. 20

9 a.m.—Registration.

10:30 a.m.—Business session (for members only). Reports of committees. Election of officers.

2 p.m.—Papers: "Practical Education of Steel Mill Electricians," W. A. Cornwell; "Relation of Standardization in Electrical Equipment to Safety," Walter Greenwood.

TUESDAY, SEPT. 21

10 a.m.—Papers: "Power Transmission for Industrial Plants," D. M. Petty; "Underground Transmission," A. L. Freret.

2 p.m.—Excursion.

WEDNESDAY, SEPT. 22

10 a.m.—Papers: "Some Considerations in the Determination of Auxiliary Drives," Gordon Fox; "Report of Electrical Development Committee for 1920, E. S. Jefferies, chairman.

2 p.m.—Papers: "The Reversing Electric Mill Considered From the Standpoint of Tonnage," K. A. Pauly.

7 p.m.—Annual Banquet. Arrangements have been made to accommodate 1,000 guests. Ladies are especially invited.

THURSDAY, SEPT. 23

10 a.m.—Papers: "Centralized Turbine Generating Stations for Steel Mills," T. E. Keating; "Current Limit Reactance," R. H. Keil.

2 p.m.—Papers: "Report of Electric Furnace Committee for 1920," E. T. Moore, chairman.

FRIDAY, SEPT. 24

10 a.m.—Papers: "Standardization Committee Report," W. T. Snyder, chairman.

2 p.m.—Excursion.

Industrial Research on Black Pigments Used in the Rubber Industry

The Rubber Trade Laboratory (235 Plane St., Newark, N. J.) announces that an industrial research will soon be started to determine the importance and relative value of the various black coloring agents used in the rubber industry.

The investigation will include the gas blacks, lampblack, graphite, bone black and powdered coal, on the one hand, while another series of tests will be made on the pitch hydrocarbons made by treatment of gilsonite, asphaltum, petroleum residues, coal tar and stearine pitch or candle tar. Most of these hydrocarbons have become known in the rubber trade as "mineral rubber," although this is a misnomer.

The purpose of the investigation is to accumulate data which will stimulate the use of these products in the field of rubber and plastic compounds. All users of these materials are invited to write to Dr. Frederic Dannerth, director of the laboratory, concerning information they may have on the use of the products. It is known that many users have encountered difficulties in manipulating some of these products, and it is therefore hoped that chemists and superintendents will feel free to send to the Rubber Trade Laboratory such questions as have arisen. Collaborators and consumers are assured that this will not place them under any fianacial obligation to the laboratory.

Last of Surplus Gas Sold

With the recent sale of 150 tons of phosgene, the Chemical Warfare Service has disposed of practically all of its surplus gases. A sufficient reserve is being kept to be ready for use in case of an emergency. General A. A. Fries, the chief of the Chemical Warfare Service, hopes to be able to carry through a plan which will allow the sale of 25 per cent of the reserve gases each year. The gases sold are to be replaced by new gas manufactured by the Chemical Warfare Service. This will allow manufacture to proceed on a small scale, sufficient to provide training and opportunities to apply improvements. General Fries hopes to get permission to adopt the same procedure as is permitted in the Quartermaster Corps, which allows money obtained from sales of materials to revert to the funds of the corps for repurchase of fresh supplies. At present the receipts from all sales made by the Chemical Warfare Service are paid into the Treasury.

General Fries Announces Policy as to Patents

After careful consideration of the whole subject of patenting processes and devices developed in the Government service, General A. A. Fries, chief of the Chemical Warfare Service, has reached the conclusion that the Government should be entitled without charge to full benefits of such development. The employee responsible for the development would be allowed to take out a patent and reap the full benefits of its use by the public or by other governments.

General Fries points out that whether or not the United States keeps abreast with other nations in the matter of gas research depends on stimulating chemists of the Chemical Warfare Service to do their utmost. By following the policy outlined, be believes the public will obtain all the benefits from the patents that could reasonably be expected, and the inventor will not be denied a handsome reward if his discovery is of sufficient commercial value.

German Government to Release Nitrogen Supplies

According to a cablegram from Berlin, of recent date, it is planned by the government to release 30,000 to 50,000 tons of nitrogen, which has been made by the Haber process from air, to be exported duty free. The prices charged to German domestic fertilizer consumers will be reduced by the receipts of sales made abroad.

To Name Consulting Chemists

Brigadier General Amos A. Fries, head of the Chemical Warfare Service, is having difficulty in obtaining his consulting staff. While these places are honorary, General Fries insists on appointing no one who will not take the time to bring helpful thoughts and suggestions to the service. Connection with a Government bureau in a consulting capacity frequently has degenerated to the point where the bureau confers the honor and hears nothing further from its consulting engineers.

General Fries believes that there are distinguished chemists in the United States who will take an active interest in the affairs of his bureau. In laying the proposition before those who are asked to serve in that capacity, he makes it clear that he will expect frequent suggestions from them. If they will submit problems, he will furnish the young chemists to follow them up.

Prize for Method for Hardness Determination

Sir Robert A. Hadfield has placed in the hands of the Institution of Mechanical Engineers, 11 Great George St., Westminster, London, S. W. 1, England, the sum of £200, the income therefrom to be awarded at the discretion of the Council as a prize for the description of a new and accurate method of determining the hardness of metals, especially of metals of a high degree of hardness.

Competitors should familiarize themselves with the ordinary tests of hardness, such as are described in the Report of the Hardness Tests Research Committee (*Proceedings* of the Institution of Mechanical Engineers, 1916, pp. 677-778). What is desired is the description of a research for or an investigation of some method of accurately determining hardness, suitable for application in metallurgical work in cases in which present methods partially fail.

Recommended Specifications for Green Paint — Semi-Paste and Ready Mixed

Circular 97 of the U. S. Bureau of Standards contains specifications for green paint—semi-paste and ready mixed—with special reference to chrome green paint, either in semi-paste pigment ground in linseed oil or ready mixed. The specification covers the general conditions and the maxima and minima of useful, harmful or neutral constituents and methods of sampling, and the details as to the laboratory examination and analysis. The detailed methods of preparing the reagents to be used are also given. The standard was prepared under the auspices of the Bureau of Standards and submitted to large numbers of representative paint manufacturers, and was also recommended by the United States Interdepartmental Committee on Paint Specification Standardization.

Courses in Chemical Engineering

The Bureau of Education has just issued a leaflet describing "Opportunities for the Study of Engineering at American Higher Institutions." This is prepared to assist foreigners desiring to enter technical collegiate work in the United States, but affords also a valuable list of the institutions in this country where 4-yr. courses in various branches of engineering are conducted. Those where a chemical engineering course is given, leading to a degree, generally Bachelor of Science in Chemical Engineering, are shown in the following table, together with a statement of the total engineering enrollment of the institution—i.e., the enrollment including civil, electrical, mechanical and others, as well as chemical engineering. However, this list does not include institutions where there are given chemical courses not classed as chemical engineering:

Institution	Total Engineering Enrollment
Alabama Polytechnic Institute, Auburn, Ala.	543
University of Alabama, University, Ala.	201
University of Arkansas, Fayetteville, Ark.	177
University of California, Berkeley, Cal.	1,340
Throop College of Technology, Pasadena, Cal.	337
University of Colorado, Boulder, Col.	531
Sheffield Scientific School (Yale University), New Haven, Conn.	531
Catholic University of America, Washington, D. C.	160
George Washington University, Washington, D. C.	461
University of Florida, Gainesville, Fla.	145
Georgia School of Technology, Atlanta, Ga.	1,160
University of Idaho, Moscow, Idaho.	115
Armour Institute of Technology, Chicago, Ill.	639
University of Illinois, Urbana, Ill.	1,712
Purdue University, Lafayette, Ind.	1,691
University of Notre Dame, Notre Dame, Ind.	215
Rose Polytechnic Institute, Terre Haute, Ind.	236
Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa	1,030
State University of Iowa, Iowa City, Iowa	368
University of Kansas, Lawrence, Kan.	649
Louisiana State University and Agricultural and Mechanical College, New Orleans, La.	—
Tulane University of Louisiana, New Orleans, La.	220
University of Maine, Orono, Me.	518
Harvard University, Cambridge, Mass.	—
Massachusetts Institute of Technology, Cambridge, Mass.	2,291
Tufts College, Tufts College, Mass.	400
Worcester Polytechnic Institute, Worcester, Mass.	567
University of Michigan, Ann Arbor, Mich.	1,915
Michigan Agricultural College, East Lansing, Mich.	450
University of Minnesota, Minneapolis, Minn.	1,469
University of Missouri, Columbia, Mo.	406
Washington University, St. Louis, Mo.	335
Montana College of Agriculture and Mechanic Arts, Bozeman, Mont.	180
University of Mexico, Albuquerque, N. M.	—
Polytechnic Institute of Brooklyn, Brooklyn, N. Y.	1,240
College of the City of New York, New York, N. Y.	150
Columbia University, New York, N. Y.	509
New York University, New York, N. Y.	370
Clarkson College of Technology, Potsdam, N. Y.	—
University of Rochester, Rochester, N. Y.	—
Syracuse University, Syracuse, N. Y.	328
Rensselaer Polytechnic Institute, Troy, N. Y.	920
North Carolina State College, West Raleigh, N. C.	734
Ohio Northern University, Ada, Ohio.	300
University of Cincinnati, Cincinnati, Ohio.	836
Case School of Applied Science, Cleveland, Ohio.	781
Ohio State University, Columbus, Ohio.	1,437
St. Mary College, Dayton, Ohio.	93
University of Oklahoma, Norman, Okla.	320
Oklahoma Agricultural and Mechanic College, Stillwater, Okla.	159
Lafayette College, Easton, Pa.	279
Bucknell University, Lewisburg, Pa.	304
University of Pennsylvania, Philadelphia, Pa.	687
Carnegie Institute of Technology, Pittsburgh, Pa.	1,655
University of Pittsburgh, Pittsburgh, Pa.	500
Lehigh University, South Bethlehem, Pa.	807
Rhode Island State College, Kingston, R. I.	183
Clemson Agricultural College, Clemson College, S. C.	409
University of Tennessee, Knoxville, Tenn.	189
University of Texas, Austin, Tex.	542
Agricultural and Mechanical College of Texas, College Station, Tex.	800
Rice Institute, Houston, Tex.	232
University of Utah, Salt Lake City, Utah.	307
University of Virginia, Charlottesville, Va.	238
State College of Washington, Pullman, Wash.	326
University of Washington, Seattle, Wash.	—
West Virginia University, Morgantown, W. Va.	580
University of Wisconsin, Madison, Wis.	1,075

Chemical Warfare Display Interests Public

The chemical warfare display, which was a part of the so-called shows given by the First Division on its journey from Camp Taylor, Ky., to its new home at Camp Dix, N.J., proved to be the most attractive feature of these entertainments. The use of colored smokes, signal rockets and flame throwers gave the public its first opportunity to see how chemical warfare is conducted. Stokes mortars were used to throw phosphorus and thermit bombs. This feature of the entertainment also proved very interesting to the crowds who watched the maneuvers.

War on Rats With Poison Gas

Rat extermination by the use of the poison gases of warfare is believed to be feasible under certain conditions, as a result of experiments conducted by the Chemical Warfare Service. The experiments were undertaken at the request of authorities at Gulf ports, where the occurrence of bubonic plague has made rat extermination imperative.

In one of the experiments a small cylinder of a mixture containing 30 per cent phosgene and 70 per cent chlorine gases was permitted to escape so as to spread over an area of 900 sq.ft. in which there were fifteen rats. In fifteen minutes the phosgene had been dissipated and in thirty minutes the chlorine could no longer be detected. All of the rats in the area were dead. The cost of the gas was 40c. and in thirty minutes the area could be frequented with entire safety by human beings.

As a result of this and other experiments, it is believed that an important new use has been found for these war gases. The fact that they are heavy and sink into depressions under docks and into cellars, sewers and other places which harbor rats is expected to solve the most serious problem that has confronted rat extermination by the methods heretofore used.

The use of irritating gases in breaking up crow roosts in the forest reserves also is being tried by the Forest Service. The existence of these roosts frequently makes it almost impossible to cultivate agricultural lands in their vicinity. The crows are very persistent in clinging to their established nesting places. It is believed that war gases can be used effectively in combating that pest. Experiments are also in progress looking to the use of gases in fighting grasshoppers and locusts.

Authorized to Buy German Dyes

The Government has decided to exercise its option on German impounded stocks of dyestuffs and has authorized the Textile Alliance, Inc., to purchase these stocks in the interest of the American consumer. The full official statement, issued by the War Trade Board Section of the Department of State, is as follows:

The United States Government, through the War Trade Board Section of the Department of State, has, in the interest of the people of the United States, authorized the Textile Alliance, Inc., of New York City, to undertake, *without profit to itself*, the following action in connection with Reparation dyes:

(1) To purchase certain dyes, being the final apportionment of impounded stocks covered by inventories of German manufacturers as of Aug. 30, Sept. 5, 19 and 27, 1919, in order that certain dyes which are not manufactured in this country and which are included in these impounded stocks might not be lost to the United States with detriment to American interests.

(2) To purchase dyes from the present existing stocks manufactured by Germany between the dates of Feb. 1, 1920, and June 30, 1920, both inclusive, in order that certain dyes which are not manufactured in this country and which are included in these stocks might not be lost to the United States with detriment to American interests.

(3) If found to be necessary and advisable to purchase such dyes as may be required and ordered through it by American consumers from future daily production of German manufacturers for the four and one-half year period commencing July 1, 1920.

(4) The authority of the Textile Alliance, Inc., to resell to American consumers the dyes acquired as above provided is subject to strict provisions regarding selling price and manner of sale for the purpose of insuring fair and equal treatment to all consumers who may wish to avail themselves of the opportunity offered.

The Government has decided to exercise its option upon German impounded stocks and has authorized the Textile Alliance, Inc., to purchase these stocks in the interest of the American consumer. Under existing regulations of the War Trade Board Section no dyes from these stocks may be imported by the Textile Alliance, Inc., which are either manufactured here or for which suitable substitutes are manufactured here on reasonable terms as to price, quality and production. No consumer will be allowed to receive more than a six months' supply of any dye at any one period from this source. Practically the same understanding is in effect regarding the daily production of the German factories from Feb. 1 to July 30, 1920.

Regarding the subject of future daily production, the Department of State has received information which would indicate that for some time to come the German factories will not be in a position to supply all expected requirements of the Allied and Associated countries and to fill Government orders emanating from these sources. If these indications are correct it would appear that unless this Government indicated a desire to exercise its option on future daily production and should render available machinery which would make it possible for American consumers, if they so desire, to obtain colors from this source, the American consumer might not be able to get such German dyes as he required. The consumer should clearly understand that he is not obligated or even advised to place orders through the machinery made available by the Government. If he believes that German dyes may be obtained from unofficial sources he may, subject to the then existing import regulations, either order such dyes as he needs direct from the German manufacturer or through such agent or agency as he may designate.

If the consumer, however, cannot obtain or believes he cannot obtain dyes by other means the Government can exercise its option on the subsequent daily production of the German factories and the Textile Alliance, Inc., can transmit his orders for purchase from official sources.

Experiment With Steel Plate for Canning Purposes

In an effort to determine the best type of base steel plate for use in making tinplate for canning purposes, the chemists of the American Canners' Association are directing an extensive series of experiments, in which they have the co-operation of the American Can Co. and the Granite City Enamel & Stamping Co.

Tests are being made under commercial conditions of the effects of fruit acids on the various types of steel plate. Previous experiments have shown that the weight of tin with which the steel is coated makes slight difference in the resistance of the can to the corrosion of the acids.

Experiments are being made, among others, with a copper-bearing plate killed with silicon, and with titanium-bearing plate.

In this connection, attention is called to the fact that the amount of tin which will produce a toxic effect is not well established. The tin which is dissolved into the contents of a can of acid-bearing food is for the most part in an insoluble condition and probably is not absorbed by the system.

Water Conservation Committee of Engineering Council Offers Services to Power Commission

The water conservation committee of Engineering Council has offered its services to the Federal Power Commission in an advisory capacity on technical matters. Calvert Townley is the chairman of the committee. Other members are Charles T. Main, H. Hobart Porter, M. O. Leighton, Allen Hazen, Arthur P. Davis, Arthur E. Morgan and F. W. Scheidenhelm.

Civil Service Examinations

The United States Civil Service Commission announces open competitive examinations to fill various vacancies in the departments as listed below:

Assistant examiner, Patent Office.
Metallurgical laboratorian.
Laboratory aid.
Laboratory assistant, intermediate grade, $1,080 a year.
Laboratory assistant, junior grade, $1,000 a year.
Senior aid, $900 a year.
Associate physicist qualified in physical metallurgy, $2,000-$2,800.
Assistant physicist qualified in physical metallurgy, $1,400-$1,800.
Assistant metallurgist (Bureau of Mines), $2,000-$3,000.
Catalytical chemist, $3,000-$4,000 a year.
Assistant catalytical chemist, $2,000-$3,000 a year.
Junior catalytical chemist, $1,600-$2,000 a year.
Chemist, $3,000-$4,000 a year.
Associate chemist, $2,000-$3,000 a year.

Further information may be had by writing to the Civil Service Commission, Washington, D. C.

Old Hickory Powder Plant Bids Postponed

The Director of Sales of the War Department announces that the date for receiving bids for the Old Hickory powder plant, near Nashville, Tenn., has been postponed from Sept. 2 to Sept. 30. This postponement was found necessary because of the large number of inquiries received and the magnitude of the proposition.

Old Hickory, which is a great modern plant and industrial town, was constructed for the manufacture of smokeless powder and explosives, but its several units are readily adaptable to many industries including chemical, rubber goods, such as auto tires; pulp and paper mills, sugar refinery, coking and coke byproducts, food, both evaporated and concentrated; iron and steel foundries, fibrated products, such as asphaltum shingles; aluminum, wood box or refrigerator manufacture, cellulose and photographic film manufacturing and a number of other minor industries, such as an ice plant or cold-storage warehouse.

Lead and Zinc Experiment Station

Lead and zinc problems will be studied at a new Bureau of Mines mining experiment station, which probably will be located at Rolla, Mo. The exact problems which will be taken up at the new station will not be determined until after a conference in St. Louis on Oct. 9 between officials of the bureau and representatives of the lead and zinc industries interested.

The laboratories probably will be located at Rolla, but the business office of the station will be in St. Louis. The name of the station will be the Mississippi Valley Experiment Station. At this writing the Secretary of the Interior has not approved the location of the station, but it is regarded as practically certain that he will have no objection to the selection of Rolla as a site for its laboratories.

C. W. S. Needs $10,000,000 Appropriation

Fully $10,000,000 will be required during the next fiscal year to carry on the work of the Chemical Warfare Service on a scale commensurate with the needs of the national defense, in the opinion of chemists who are following the work of the Service. Of that amount it will be advisable, it is estimated, to expend as much as $2,000,000 for research.

C. W. S. Will Need More Officers

The need of the Chemical Warfare Service in the matter of officers will not be met when the results of the recent examination for commissions are announced. Although more than 200 appeared for the examination, a considerable number failed to pass the physical examination or were disqualified for other reasons. Only about 100 completed the examination. It is certain that a considerable percentage will fail to make the requisite grades. The results of the examination have not been announced but, judging from similar examinations which have been held in the past, those failing to make passing grades vary from 60 to 80 per cent. Ninety-five officers are needed for duty with the Chemical Warfare Service. A very high standard has been required in the examinations.

Personal

A. N. JOHNSON will leave the Portland Cement Association Oct. 1 to take up new duties as dean of the Engineering School and director of engineering research at the University of Maryland, College Park, Md.

PAUL D. V. MANNING has joined the chemical staff of the International Coal Products Co. Newark, N. J. He formerly was with the Chile Exploration Co.

MORRIS METCALF has been appointed president and a director of the International Steel Corporation, 51 Chambers St. N. Y., a subsidiary of the American International Corporation.

KENNETH P. MONROE has resigned as chemist in the color laboratory, United States Bureau of Chemistry, Washington, to accept a research position in the Jackson Laboratory of E. I. du Pont de Nemours & Co., Wilmington, Del.

Dr. R. B. MOORE, chief chemist of the Bureau of Mines, has returned to Washington after an extended trip to the Western experiment stations of the Bureau of Mines.

Dr. E. F. NORTHUP has resigned his professorship at Princeton University to devote his entire time to the business of the Ajax Electrothermic Corporation, Trenton, N. J.

H. B. PULSIFER, who was formerly professor of metallurgy at the Montana School of Mines and state metallurgist, will be an assistant professor of metallurgy at Lehigh University, Bethlehem, Pa., commencing with the academic year 1920-21.

DAVID B. REGER, of Morgantown, W. Va., is on leave of absence from the West Virginia Geological Survey for the next few months and will devote that time to consulting work in petroleum and coal. He has just completed a month's trip to the prospective oil fields of Montana.

HARRY B. RIFFENBURG, formerly assistant professor of chemistry and chemical engineering at the Agricultural and Mechanical College of Texas, resigned on Sept. 1 to accept a position as junior chemist in the quality of water division of the water resources branch of the U. S. Geological Survey, Washington D. C.

Dr. LUDWIK SILBERSTEIN, formerly of Adam Hilger, Ltd., London, is now associated with the research laboratory staff of the Eastman Kodak Co. Dr. Silberstein is known for his mathematical papers dealing with electro-magnetism, optics, theory of relativity, projective geometry, spectrum theory, etc.

F. L. STACK has left the Cia. de Santa Gertrudi at Pachuca, Mexico, to join the staff of the Chile Exploration Co. in New York.

Dr. WALTER F. TAGGART, for many years professor of organic chemistry at the University of Pennsylvania, has been elected to succeed Dr. Edgar Fahs Smith, who resigned last June as Blanchard professor of chemistry at

that institution. Prof. Taggart is now head of the chemical department of the university.

G. M. WILLIAMS, who has been for a number of years a specialist in the cement investigations of the Bureau of Standards, has resigned to accept an assistant professorship in civil engineering at the University of Saskatchewan. Mr. Williams has been particularly engaged in the work of cement protection in regions where alkali waters prevail, having had an active part in the joint investigations of the Reclamation Service, the Department of Agriculture and the Bureau of Standards. It is expected that the Canadian work of this sort which is under way will receive Mr. Williams' active attention for some time to come, in connection with his university activities.

Book Reviews

SCIENCE AND LIFE. Aberdeen addresses by *Frederick Soddy*, M. A., F. R. S.: Dr. Lee's professor of inorganic and physical chemistry, University of Oxford; lately professor of chemistry, University of Aberdeen. 229 pp. New York: Dutton & Co., 1920.

This book is a collection of articles published and addresses made during Prof. Soddy's incumbency of the chair of chemistry at Aberdeen, and it includes the following subjects: Chemistry and Life; Chemistry and National Prosperity; Science and the State; The Future of Science and What Bars the Way; The Evolution of Matter; The Conception of the Chemical Element as Enlarged by the Study of Radioactive Change; Matter, Energy, Consciousness and Spirit; To the New Launch and the Ideals of a Science School. It concludes with an appendix in which the method of administering the Carnegie Trust for the universities of Scotland is subjected to fearless and lively criticism, and a report of the controversy that followed it.

The several essays are rather loosely put together, and there is a slight measure of repetition in them; but this is no fault. Prof. Soddy is a believer in the mission of science; many of the addresses were made during the war, and he spoke from the very depths of his soul, with no effort to hide the emotion which prompted him to issue his call. He tells with marked eloquence the gifts that science has made to humanity, and then he asks what we have done with these gifts. "The strong," he says, "have fed and grown fat upon a large and ever larger share of the manna (from science). Initial slight differences of strength and sagacity have become so emphasized by the virile stream that the more successful are becoming monstrously so, and the unsuccessful less able to secure a full meal than before the shower began." This, it would seem, might be the beginning of radical political propaganda, but it is not. The burden of his complaint is not against political conditions; these do not seem to worry him. His complaint is that we do not know enough; that our education is faulty. He blames our reactionary method of education. "Is there," he asks, "a single practical branch of human thought or knowledge which has been left untouched; nay, more, which has not been altered to its very foundations by the progress of science?" And the reply is, "The education of those to whom, for the most part, is entrusted the happiness and the destiny of nations ceases where it should begin!" He insists that science must not only be taught, but understood, if we are to meet the great obligations of the future.

"The wealth of a country," he says, "is in its matter and energy—matter, the passive resister that in the raw state will not do anything you want it to do; and energy, both animate and inanimate, which is forever trying to do what you do not want it to do, and needs to be controlled. So man found the world, and so, largely till the beginning of the last century, he left it, moralizing and philosophizing eternally about himself and leaving a vast legacy of these elegant accumulations for the 'education' of his children." And he declares we must break the entail of dead languages.

"Let us glance at the change that has come over the world with regard to the relations of man to energy and matter. Instead of being between the two as between a steam hammer and an anvil, man has climbed to the controlling gear and has his hand upon the valve. And the hands on this valve are the hands of the chemist and the physicist, and their executive officer, the engineer."

He recognizes the possibility of developing power from breaking down atoms of the heavier elements and he even hopes that with the immense capacity for use and destruction that will come with this achievement it may not be too soon at hand. For we are not ready to wield such power. We are not yet good enough.

The book is of special interest to men of science, because it brings out their immense burden of responsibility. He says that the elevation of human ideals and the inspiration of character has not progressed to keep pace with the growth of physical power at hand. For power is everything. We live on it, developing it very much as a steam engine develops it from fuel. When we get our power in immeasurable quantities we shall have such capacity to do harm that it may be we are better off without it. It would be well also for the educator to read the book. If he is a classicist it may worry him, but he will be unable to resist the demand to ask himself whether he is making his own work worth while.

The chapters on radioactivity are beautifully written, and, coming from Prof. Soddy; are authoritative.

ELLWOOD HENDRICK.

* * *

SURVEYING. By *W. Norman Thomas.* 536 pp. 18 chapters. London: Edward Arnold; New York: Longmans, Green & Co.

The latest surveying science as practiced in England is amply presented. While this text is not in the same class from an engineering viewpoint as the leading standard American treatises, nevertheless it can be read with profit by our surveyors who have the desire to import new ideas and incorporate them in their practice.

WALLACE SAVAGE.

Current Market Reports

The Iron and Steel Market

Pittsburgh, Sept. 10, 1920.

It has become obvious that the peak has been passed in iron and steel demand and in prices, but no early cessation is to be expected in furnace and mill activity, nor are prices likely to decline in the near future.

Apparently it required the passing of the midsummer period to show conclusively that the market lacked fundamental strength. July and August are always very dull months in the iron and steel markets, hence the dullness in the bimonthly period just ended attracted much less attention than it would have attracted at any other time in the year. If the season of year were the governing influence, the passing of time would have brought an increase in activity, but the actual condition is one of stagnation.

EFFECT OF NORMAL RAIL TRAFFIC RESTORATION

A question that was a puzzling one a few weeks ago has now been answered, what would be the effect upon business, and upon steel demand in particular, of a restoration of rail traffic conditions to something like a normal basis, whether that would stimulate business by making it easier to do business, to produce and consume, or would put a damper on business by causing consumers to depend more upon their stocks. It may be difficult to establish precisely the connection between the improvement in rail traffic conditions and the present state of the iron and steel markets, if indeed there is any important connection, but at any rate two things have occurred, the rail situation has become almost normal and the iron and steel markets have become patently dull.

The condition is simply one of abstention from buying. Consumers are content with the material that is already due them on purchases and are indisposed to make additional commitments. Here and there some demand exists for early deliveries, but the total tonnage is not large and the material is wanted simply to "piece out."

CANCELLATIONS OF STEEL ORDERS

Much reference is made to cancellations that have occurred, or are likely to occur, of steel orders. The situation in this respect is much like what has obtained in the past after a great market movement. There are cancellations, but they involve no large tonnage in proportion to the total on mill order books. Each arises from some special condition obtaining with the buyer, so that the cancellations that have occurred are by no means typical or illustrative of a general condition. In the main the material that has been ordered is actually required to carry out engagements the buyer has made.

NO DECLINING TENDENCY IN PRICES

There is no general declining tendency in prices of either pig iron or steel products. Some developments might be cited as indicating declines, but they would not be a real criterion. There have been several different markets, first the Steel Corporation market, at the Industrial Board prices that became effective March 21, 1919, and then several different markets among the independents. Some independents sold to regular customers at prices that have changed scarcely at all since the advance culminated early in the year. Other independents sold at approximately all they could secure, but only to regular customers. Others still made no distinction between strangers and those who had been regular customers. In this last-named market some declines might be found, but that is of no consequence. The producers that have maintained more or less steady prices are adhering still to those prices and possibly they are a shade stiffer than they were.

Except as to one matter, the whole steel market presents an appearance strikingly similar to conditions that have obtained at various times in the past when there had been an active buying movement with advancing prices. There is the same quiet market, the same maintenance of prices and the same willingness of buyers to accept deliveries on old contracts while they will not make additional commitments. The one exceptional feature is that the United States Steel Corporation, which makes about 44 per cent of all the steel, has no connection with the situation. It did not advance prices, and it is sold, in proportion to capacity, probably at least twice as far as are the independents. The corporation experiences few if any cancellations.

Just as has been the case at similar junctures in the past, the mills are indisposed to reduce their prices. Little if any business would be attracted, and the filling of the business now on books would be jeopardized more or less.

OUTLOOK IS FOR FULL OPERATION TO END OF YEAR

The only important question at this time is how long the momentum will carry the situation. The mills are operating as full as they can and have been shipping not only their current output but much of the material accumulated in the four months April to July, when it was impossible, on account of rail traffic conditions, to ship all the output. The various experiences of the past have been that a stagnant market is not followed quickly by lessened production. The mills run their orders and the momentum carries them for quite a while. At the moment the outlook is that there will be substantially full operation to the end of the year, and quite possibly through the winter. The prices of independents may not decline for months, and when they do decline they will probably decline rapidly.

THE PIG IRON MARKET

It has required only a very short time to make it plain that the recent advance in pig iron in various districts was not justified from any conservative viewpoint. Pig iron, being made to sell, is not benefited by a paper price, and the $50 level to which pig iron was pushed in several districts is a price on paper but a price at which little iron has been sold or is likely to be sold. Pig iron was already too high in relation to steel products and in relation to pre-war prices. Apart from that, some developments may be mentioned. The production of merchant pig iron increased by about 7 per cent from July to August, and to a rate that has been exceeded for only a few weeks at any time in a year and a half, while there are some idle furnaces ready to go into blast if they can secure coke, but they require the coke at a price much below that at which there would be left a good margin of profit on pig iron sold at $50. Another development is that two districts, Chicago and Birmingham, have not followed the advance. Chicago remaining at $46 and Birmingham at $42. That is not because the producers in those districts were unable to force their prices up, but because their judgment was that it was best not to do so. Even with the stiff advance in freight rates Birmingham iron could get into Pittsburgh and beat valley iron by over $2 in the delivered price, whereas in the past few years Birmingham iron has rarely been able to get into Pittsburgh.

Two other developments bearing upon the future of pig iron prices may be mentioned. The Steel Corporation has some pig iron production at Milwaukee that is sold as merchant iron, and the corporation has just set a price of $39, furnace, on its fourth quarter deliveries, these being confined, of course, to regular customers. The corporation also has some merchant production in the Birmingham district, on which its price has not gone above $38, Birmingham, and it is now announced that on Oct. 1 two more furnaces will be put into the merchant class, as their output will no longer be needed for the steel works.

The Chemical and Allied Industrial Markets

New York, Sept. 10, 1920.

Two weeks have gone by since the last market report in these pages, yet conditions have changed but little. Prices are no firmer; in some lines there has been a decline, while buying is practically at a standstill.

Spot supplies are mostly of those items which have been less active than the others in the past, and holders are consequently still finding difficulty in disposing of this material even with the concessions being granted. *Caustic potash* still remains firm around 28c. per lb., with very little obtainable for spot demand and producers pretty well sold up for some time to come. On the other hand, *caustic soda* and *soda ash* are somewhat weaker. Although former prices of $5.60@$6 per cwt. for the former and $3.20@$3.60 per cwt. for both grades of the latter still prevail, nevertheless those who do not seem to agree with these prices are remaining quiet. *Copperas* and *barium chloride*, two recently active items on the list, are now in better supply and quantities of the former can be obtained around $2 per cwt., although $2.25 seems to be the more average price, while *barium chloride* has come to $130, compared with a former low level of $150 per ton. *Arsenic* continues rather dull, with very little business recorded, at 14@16c. per lb. for the white grade and 17@19c. for the red. *Bleaching powder* maintains the firm tone which has been noticed for some time and is obtainable only in small lots at $7@7.50 per cwt., which is 50c. better than the last listing. The intention of the comment on the above items is to indicate that tendency of chemical prices at present is not upward.

COAL-TAR PRODUCTS

All that has been said in the previous paragraph applies to this market and to avoid repetition it is sufficient to say that the condition is little more acute in this case. There is small room for doubt that the crudes would be more active if they were in better supply, as the demand for these continues brisk, but producers are handicapped under present labor conditions and are contracted for a considerable length of time in advance. The opposite is true of the intermediates. Supplies are greater than requirements at present and buyers, realizing this situation, are holding out for lower prices. Among the intermediates to come down during the period was *dimethylaniline*, which dropped to

80@90c., compared with the former quotation of $1@$1.05 per lb. *Beta naphthol*, technical, was also affected by this inactivity and dropped off 5c. per lb., from 85@95c. to the present listing of 80@85c. per lb. In line with the others *paranitraniline* is weaker, being available at $1.10@$1.15 per lb., with the possibility of still lower prices in large quantities, compared with the previous firm quotation of **$1.10@ $1.20 per lb.**

NAVAL STORES

Turpentine started on the decline about a week back and has been dropping steadily since then. Current quotations range around $1.49, against the previous quotation of $1.55 per gal. The slackening of foreign demand is responsible for this condition, which it seems will prevail a while at least. Savannah, which influences the local market, is quoted at $1.43 and is on the decline, being supported by the local buying, which in itself is not very heavy.

VEGETABLE OILS

This market is very much weaker than it was two weeks ago. No interest is being displayed by buyers even at the present low levels. Crushers are stocked up and are unable to dispose of their supplies. Noticeable declines occurred in *chinawood oil* in barrels, f. o. b. Pacific coast, listed at 14¾@16c. per lb. *Linseed* is also considerably weaker, being quoted at $1.22 per gal. as the general quotation, while it is rumored sales have gone as low as $1.10 per gal., for which level buyers seem to be waiting.

The Baltimore Market

Baltimore, Md., Sept. 8, 1920.

Purchasing of raw fertilizer materials on the local market for the past few weeks has been practically at a standstill. This has been due in part to the manufacturers' inability to get cars for shipping the finished products, also the general weaker tone in the market for many raw materials.

Now that the new freight rates have gone into effect, the local trade generally expects a greater supply of cars and a consequent speedier movement of mixed goods and raw materials. It is generally felt that the bearish condition is due to the tight money situation, rather than an excess supply or lack of demand.

Since our last letter a fire occurred at the plant of the Standard Guano Co., Curtis Bay, this city, which resulted practically in the complete loss of the bone mill, tankage house and a large stock of raw materials; this loss has been estimated at $250,000. Fortunately, the acid plant and adjoining properties were uninjured.

ACID PHOSPHATE

Acid phosphate continues to be strong in demand, with the market showing no weakness. Bulk acid phosphate, run of pile, is being nominally quoted at $20 per ton, basis 16 per cent A. P. A., f. o. b. Baltimore. Sales for spot parcels have been reported at somewhat higher figures. A number of recent inquiries for spot goods have failed to result in business because of the sellers' inability to get cars for shipment. The labor situation at the mines does not seem to have been appreciably improved, and as a consequence the raw rock shortage continues and a generally firm price for acid phosphate for spring is expected.

NITRATE OF SODA

The nitrate of soda market for nearby deliveries continues to work lower. Spot parcels, Southern ports, are being offered at $3.65, and in some cases sellers are soliciting bids. Spot parcels may be had locally around $3.75, and it is believed that delivery up to Jan. 1 could be had around the same figure. Importers are quoting nominal for forward deliveries at $3.80 Atlantic ports. Reselling of nitrate by Japan has been effected on rather a large scale; purchases made by local manufacturers were on a basis of ex vessel Pacific port; the prices paid, however, figured closely in line with the quotations given here.

POTASH

The demand for potash on the local market is quite limited at this time, and a number of resale lots of various grades of foreign salts are being offered for spot and nearby deliveries. Nominal quotations for August, September, October, arrival Atlantic ports, are as follows: Muriate potash, $2.35 per unit; manure salts and kainit, $1.95@$2.05 per unit K_2O; for November forward sellers are generally asking a premium of 10 to 15c. per unit. Domestic potash is being quoted nominally at $2.25 per unit f. o. b. mines for delivery November forward.

SULPHATE OF AMMONIA

A number of resale parcels of sulphate of ammonia from Japan are still in evidence. The last offerings noted were at $5.55 per cwt., bulk, basis Baltimore rate of freight.

FISH SCRAP

Menhaden fishing on the Chesapeake Bay during the past few weeks has been generally poor. The fish have been running uniformly low in oil, and as a consequence the fish factories are greatly disappointed in the results obtained so far this season. The production of scrap has been sold ahead at a uniform price of $7.50 and 10c. f. o. b. factories.

Due to the shortage in production and the steady demand for scrap, no weakening in this market is expected for the immediate present.

The Chicago Market

Chicago, Sept. 8, 1920.

In practically all lines the local chemical market is apparently in the doldrums. Instead of being surprised and disappointed at this condition, all parties concerned are sufficient students of economy to realize that it is inevitable and are complacent in the knowledge that they have so disposed their resources as to be able to get through this stagnant period with no real financial difficulty.

Sharp observers early in the spring saw that in the flood of orders being booked in all manufacturing lines a great many duplications and inflations were creeping into the swollen back order files, and that cancellations and a scaling down of orders must necessarily occur. The present slackness of trade is felt to be the natural reaction from the super-prosperity of the spring season, and as the chemical industry furnishes the basic raw materials in many lines, this slackness is naturally most keenly evident in the chemical trade.

One good feature of the current depression is the elimination of the numerous "vest pocket manipulators," dealers in chemicals whose stock in trade consisted of a list of obtainable supplies, whose participation in the trade tended only to increase the difficulties of legitimate buyers and sellers, to the profit of the speculators alone.

All consumers are today marking time—buying only sufficient materials to keep production up to the necessary mark, and in many lines that mark has been placed considerably lower than it was a few weeks ago. The price recessions on many lines are sharp, but quotations are still above what is felt to be the real intrinsic value of the commodities concerned, so that lower levels may be expected before business again strikes a normal stride.

HEAVY CHEMICALS

Trading is negligible. Those items which are firmly held in first hands remain steady in price, but those of which any great supply is in the hands of re-sellers are uncertain. With the exception of bleaching powder, the alkalis are showing little activity and are not strongly held. *Bleaching powder*, being very scarce and in need by the users, is worth whatever the customer can be compelled to pay. Small lots are being sold at prices ranging from 7@8c. per lb. *Caustic soda*, under slack demand and improved supply, is offered at 5c. per lb. on spot, and it is probable some shading is being indulged in. *Soda ash* and *sal soda* are in a similar position, current quotations being slightly lower at 5c. and 2c. per lb., respectively, for sales from stock. No great activity can be expected in this class of material until makers announce contract prices for next spring.

But few items of interest are noted in the remainder of

the heavy chemical line. *Salt cake* is not available in sufficient quantity to supply all demands, though contracts are being filled. Trades in spot goods are running up to $50 a ton in car lots. *Arsenic,* as indicated in the last report, is off a cent to 14c. per lb. on the *white* and 18@18½c. per lb. on the *red. Copper sulphate* (blue vitriol) is firm at 9c. in cars and *copper carbonate* is still quoted at 27c. by both first and second hands with but few transactions noted.

Alcohols of all grades are unchanged in price while *formaldehyde,* under influence of a strong Eastern market, is quoted at 55c., with no great amount of sales. Holders and users of *glycerine* seem to differ in their opinion as to its worth, with a poor market at 28c. for c.p. grade as the result.

COAL-TAR PRODUCTS

Retreachments in the textile industry are having their effect in keeping interest in color products at a low ebb. With the exception of *aniline oil* and *aniline salt,* no fluctuations of moment have been noted. These two items, in a very weak market, registered further declines and are easily obtainable at 25@26c. for the *oil* and 35½@36c. for the *salts.* Improved demand for oil has brought quotations up to 28c., but the *salt* continues as low as or even lower than before. Predictions of higher prices are heard, but it is difficult to find any facts to substantiate them. Prices on coal-tar crudes and acids are level, but with little trading being indulged in.

VEGETABLE OILS

Trade in all items of the list is very dull. Soap makers, paint makers and consumers of edible oils alike express themselves as satisfied to produce only sufficient finished product to fill actual orders and in many instances have sufficient raw material on hand to supply their needs for some time to come. In the face of a falling market no one can find justification for keeping up a heavy reserve stock, hence actual trading is at an exceedingly low level. *Cottonseed oil* last week reached a sufficiently low level to invite some investment. Prices are therefore fairly firm at 10¼@11¼c. per lb. on prime summer yellow and 15¼@15¾c. per lb. on refined, deodorized. *Red oil,* under pressure of a lack of buyers, is given a nominal quotation of 13@13½c. with but few sales recorded, and *corn oil* excites no interest at the current quotation of 9c. Some buying by consumers is noted in *coconut oil* at 13@13½c. per lb. in sellers tanks, f. o. b. coast, and at 16@16½c. f. o. b. Chicago for Manila grade. The refined grade is 1c. higher. But little interest is displayed in *soya bean oil,* current transactions being reported at the unchanged price of 9½c. per lb. f. o. b. coast.

Linseed oil remains of uncertain value, the effect of low quotations on futures being very keenly felt. Holders of spot stocks decline to do business at less than $1.40 per gal., so that few actual transactions are being made.

Offers of *linseed oil* for future delivery at low prices have affected spots to such an extent that current quotation in tank cars, f. o. b. Chicago, is $1.15 per gallon. In barrels the price is 7c. higher. As futures are offered at still lower figures, the low prices have failed to induce heavy buying.

NAVAL STORES

Gradually falling prices, accompanied by a practice of hand-to-mouth buying by principal consumers, has made the local market in *turpentine* and *rosin* weak. *Turpentine,* under a plentiful supply, is off to $1.48@$1.55 for barrels in car load lots, f. o. b. Chicago. In quantities of from one to twenty barrels, quotation is 7c. higher. The prevailing weakness has also affected *rosins,* which three weeks ago were quoted at $16 per barrel in l. c. l. quantities on all grades. Today $14@$14.25 is quoted on WW grade with darker grades from 25c. to 35c. cheaper. Owing to insistent demand, market on pine oil remains firm at $1.90 per gal. This is one item of the line that needs no stimulation of foreign buying to maintain strength, as the best efforts of the producers are inadequate to supply the needs of our own country.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

		Carlots	Less Carlots
Acetic anhydride	lb.		$0.65 – $0.75
Acetone	lb.	$0.15 – $0.20	.21 – .22
Acid, acetic, 28 per cent	cwt.	3.50 – 3.75	4.00 – 4.50
Acetic, 56 per cent	cwt.	6.50 – 7.50	8.50 – 9.50
Acetic, glacial, 99½ per cent, carboy	cwt.	14.00 – 16.00	16.25 –
Boric, crystals	lb.	.15½ – .16	.16½ – .19
Boric, powder	lb.	.15½ – .16½	.17 – .20
Citric	lb.	.78 – .80	.82 – .84
Hydrochloric (nominal)	cwt.	2.25 – 3.00	3.10 – 4.00
Hydrofluoric, 52 per cent	lb.	.13½ – .14	.14½ – .15½
Lactic, 44 per cent tech.	lb.	.10 – .11½	.12 – .16
Lactic, 22 per cent tech.	lb.	.04½ – .05½	.06 – .07
Molybdic, C. P.	lb.	4.00 – 4.50	4.50 – 5.00
Muriatic, 20 deg. (see hydrochloric).			
Nitric, 40 deg.	lb.	.06 – .07	.07½ – .08½
Nitric, 42 deg.	lb.	.07½ – .08	.08½ – .09½
Oxalic, crystals	lb.	.53 – .54	.55 – .57
Phosphoric, Ortho, 50 per cent solution	lb.	.18 – .23	.24 – .25
Picric	lb.	.28 – .35	.40 – .50
Pyrogallic, resublimed	lb.	2.30 – 2.55	2.60 – 2.65
Sulphuric, 60 deg., tank cars	ton	12.00 – 16.00	
Sulphuric, 60 deg., drums	ton		
Sulphuric, 66 deg., tank cars	ton	16.00 – 17.00	18.00 – 20.00
Sulphuric, 66 deg., drums	ton	26.00 – 28.00	
Sulphuric, 66 deg., carboys	ton		
Sulphuric, fuming, 20 per cent (oleum) tank cars	ton	27.00 – 30.00	37.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) drums	ton	28.00 – 30.00	38.00 – 42.00
Sulphuric, fuming, 20 per cent (oleum) carboys	ton	32.00 – 35.00	40.00 –
Tannic, U. S. P.	lb.	1.45 – 1.50	1.55 – 1.65
Tannic (tech.)	lb.	.60 – .70	.80 – .90
Tartaric, crystals	lb.		.74 – .77
Tungstic, per lb. of WO	lb.		1.20 – 1.40
Alcohol, Ethyl (nominal)	gal.	5.50 – 5.75	6.00 – 7.00
Alcohol, Methyl (see methanol)			
Alcohol, denatured, 188 proof (nominal)	gal.		1.10 – 1.15
Alcohol, denatured, 190 proof (nominal)	gal.		1.05 – 1.10
Alum, ammonia lump	lb.	.05 – .05½	.05½ – .06
Alum, potash lump	lb.	.08½ – .08½	.09 – .09½
Alum, chrome lump	lb.	– .17	.18 – .19
Aluminum sulphate, commercial	lb.	.04½ –	
Aluminum sulphate, iron free	lb.	.06 –	
Aqua ammonia, 26 deg., drums (750 lb.)	lb.	.09½ – .10½	.11 – .12
Ammonia, anhydrous, cylinders (100–150 lb.)	lb.	.35 – .35½	.36 – .37
Ammonium carbonate, powder	lb.	.16 – .16½	.17 – .18
Ammonium chloride, granular (white salammoniac) (nominal)	lb.	.15½ – .16½	.17 – .18
Ammonium chloride, granular (gray salammoniac)	lb.	.13 – .13½	.13½ – .14½
Ammonium nitrate	lb.	.09 – .10	.11 – .14
Ammonium sulphate	lb.	.07 – .07½	.08½ –
Amylacetate	gal.		5.00 –
Amylacetate tech	gal.		4.75 – 5.25
Arsenic, oxide, lumps (white arsenic)	lb.	.14 – .16	.16½ – .17
Arsenic, sulphide, powdered (red arsenic)	lb.	.17 – .18	.19 – .23
Barium chloride	ton	130.00 – 150.00	
Barium dioxide (peroxide)	lb.	.21 – .23	.24 – .25
Barium nitrate	lb.	.10 – .12	.12½ – .13½
Barium sulphate (precip.) (blanc fixe)	lb.	.04½ – .05	.05½ – .06
Bleaching powder (see calcium hypochlorite).			
Blue vitriol (see copper sulphate)			
Borax (see sodium borate)			
Brimstone (see sulphur, roll)			
Bromine	lb.	.70 – .90	1.00 – 1.05
Calcium acetate	cwt.	3.50 – 3.55	
Calcium carbide	lb.	.04½ – .04½	.04½ – .05½
Calcium chloride, fused, lump	ton	33.00 – 34.00	35.00 – 45.00
Calcium chloride, granulated	lb.	.02 – .02½	.03 – .03½
Calcium hypochlorite (bleaching powder)	cwt.	7.00 – 7.50	8.00 – 8.50
Calcium peroxide	lb.		1.50 – 1.70
Calcium phosphate, monobasic	lb.		.75 – .80
Calcium sulphate, pure	lb.		.25 – .30
Carbon bisulphide	lb.	.08 – .09	.10 – .11
Carbon tetrachloride, drums	lb.	.14 – .15	.16 – .17
Carbonyl chloride (phosgene)			
Caustic potash (see potassium hydroxide)			
Caustic soda (see sodium hydroxide)			
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.09 – .09½	.10 – .10½
Chloroform	lb.	.40 – .43	.44 – .47
Cobalt oxide	lb.		2.00 – 2.05
Copperas (see iron sulphate)			
Copper carbonate, green precipitate	lb.	.27 – .28	.29 – .31
Copper cyanide	lb.		.65 – .70
Copper sulphate, crystals	lb.	.08 – .09	.09 – .09½
Cream of tartar (see potassium bitartrate)			
Epsom salt (see magnesium sulphate)			
Ethyl Acetate Com. 85%	gal.	1.10 – 1.30	1.40 –
Ethyl Acetate pure (acetic ether 98% to 100%)			1.75 –
Formaldehyde, 40 per cent (nominal)	lb.	.48 – .50	
Fusel oil, ref	gal.		5.25 – 6.00
Fusel oil, crude (nominal)	gal.		
Glauber's salt (see sodium sulphate)			
Glycerine, C. P. drums extra	lb.		.26½ – .28½
Iodine, resublimed	lb.	4.30 – 4.35	4.40 – 4.45
Iron oxide, red	lb.		.03 – .20
Iron sulphate (copperas)	cwt.	2.00 – 2.25	2.35 – 2.75
Lead acetate, normal	lb.		.13½ – .16
Lead arsenate (paste)	lb.	.11 – .12	.13 – .17
Lead nitrate, crystals	lb.		.90 – 1.00
Litharge	lb.	.14 – .15	.15½ – .16
Lithium carbonate	lb.		1.50 –
Magnesium carbonate, technical	lb.	.12½ – .13½	.15 – .16
Magnesium sulphate, U. S. P.	100 lb.	3.50 – 3.90	4.00 – 4.50
Magnesium sulphate, commercial	100 lb.		3.50 – 3.60
Methanol, 95%	gal.		3.25 – 3.30
Methanol, pure	gal.		3.50 – 3.55
Nickel salt, double	lb.		.14 – .16
Nickel salt, single	lb.		.13 – .14
Phosgene (see carbonyl chloride)			
Phosphorus, red	lb.	.50 – .55	.60 – .65
Phosphorus, yellow	lb.		.35 – .37
Potassium bichromate	lb.	.35 – .36	.39 – .40

		Carlots	Less Carlots
Potassium bitartrate (cream of Tartar)	lb.	$0.52 – $0.56	$0.57 – $0.58
Potassium bromide, granular	lb.	–	.70 – .73
Potassium carbonate, U. S. P.	lb.	.50 – .55	56 – .60
Potassium carbonate, crude	lb.	.20 – .25	.26 – .28
Potassium chlorate, crystals	lb.	.17 – .17½	.18 – .20
Potassium hydroxide (caustic potash)	lb.	.27 – 28	.29 – .33
Potassium iodide	lb.	–	3.35 – 3.60
Potassium nitrate	lb.	.17 – .17½	.19 – .21
Potassium permanganate	lb.	.75 – .80	.85 – .95
Potassium prussiate, red	lb.	.85 – .95	1.00 – 1.05
Potassium prussiate, yellow	lb.	.32 – .36	.35 – .40
Potassium sulphate (powdered)	ton	$240.00 – 255.00	–
Rochelle salts (see sodium potas. tartrate)			
Salammoniac (see ammonium chloride)		–	–
Sal soda (see sodium carbonate)			
Salt cake	ton	–	48.00 – 50.00
Silver cyanide (nominal)	oz.	–	1.25 –
Silver nitrate (nominal)	oz.	–	.60 – .62
Soda ash, light	100 lb.	–	3.20 – 3.50
Soda ash, dense	100 lb.	–	3.55 – 3.65
Sodium acetate	lb.	.10 – .15	.20 – .25
Sodium bicarbonate	100 lb.	2.50 – 2.75	3.00 – 3.50
Sodium bichromate	lb.	.22 – .24	.26 – 27
Sodium bisulphate (nitre cake)	ton	7.00 – 8.00	9.00 – 11.00
Sodium bisulphite Powered, U.S.P.	lb.	.08½ –	.10 – .11
Sodium borate (borax)	lb.	.09 – .10	.11 – .12
Sodium carbonate (sal soda)	100 lb.	2.00 – 2.10	2.15 – 2.25
Sodium chlorate	lb.	.11 – .12	.12½ – .14
Sodium cyanide, 96-98 per cent	lb.	.25 – .30	.32 – .35
Sodium fluoride	lb.	.18 –	.19 – .20
Sodium hydroxide (caustic soda)	100 lb.	5 60 – 5.70	5.75 – 6.00
Sodium hyposulphite	lb.	–	.03 – .04
Sodium molybdate	lb.	2 50 –	3.25½ –
Sodium nitrate	100 lb.	3 00 – 3.25	3.75 – 4.00
Sodium nitrite	lb.	.16 – .18	.19 – .20
Sodium peroxide, powdered	lb.	.32 – 35	.35 – .40
Sodium phosphate, dibasic	lb.	.03¾ – .04½	.04½ – .05
Sodium potassium tartrate (Rochelle salts)	lb.	–	.39 – .40
Sodium prussiate, yellow	lb.	.23 – 27	.31 – .32
Sodium silicate, solution (40 deg.)	lb.	.01½ – .01¾	.02 – .02¼
Sodium silicate, solution (60 deg.)	lb.	.02¼ – .03	.04 – .05
Sodium sulphate, crystals (Glauber's salt)	cwt.	1.60 – 1.70	1.75 – 2 50
Sodium sulphide, crystal, 60-62 per cent (conc)	lb.	.09½ – 10	.10½ – .11
Sodium sulphite, crystals	lb.	.04 – 0 4½	.04½ – .05
Strontium nitrate, powdered	lb.	.15 – 18½	.19 – 20
Sulphur chloride red	lb.	.08 – 09	.10 – .10½
Sulphur, crude	ton	16.00 – 20.00	–
Sulphur dioxide, liquid, cylinders	lb.	.09 –	.10 – .12
Sulphur (sublimed), flour	100 lb.	–	3.80 – 4.35
Sulphur, roll (brimstone)	100 lb.	–	3.40 – 3.90
Tin bichloride (stannous)	lb.	.42½ – 44	.45 – .46
Tin oxide	lb.	–	.55 – .65
Zinc carbonate, precipitate	lb.	.16 – .18	.19 – .20
Zinc chloride, gran.	lb.	.13 – 13½	.13½ – .17
Zinc cyanide	lb.	.45 – .49	.50 – .60
Zinc dust	lb.	.12 – .13	.13 – .14
Zinc oxide, U. S. P.	lb.	.17 – .25	–
Zinc sulphate	lb.	.03½ – .03¾	.04 – 06

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.40	— $1.50
Alpha naphthol, refined	lb.	1 60	— 1.70
Alpha naphthylamine	lb.	.50	— .52
Aniline oil, drums extra	lb.	.30	— .33
Aniline salts	lb.	.35	— .40
Anthracine, 80% in drums (100 lb.)	lb.	.90	— 1.00
Benzaldehyde (f.f.c.)	lb.	2.00	— 2.10
Benzidine, base	lb.	1.35	— 1.40
Benzidine, sulphate	lb.	1.15	— 1.25
Benzoic acid, U.S.P.	lb.	.85	— .90
Benzoate of soda, U.S.P.	lb.	.80	— .90
Benzol, pure, water-white, in drums (100 gal.)	gal.	.38	— .40½
Benzol, 90%, in drums (100 gal)	gal.	.36½	— .38½
Benzyl chloride, 95-97%, refined	lb.	.35	— .40
Benzyl chloride, tech	lb.	.25	— .35
Beta naphthol benzoate (nominal)	lb.	3.50	— 4.00
Beta naphthol, sublimed (nominal)	lb.	–	—
Beta naphthol, tech (nominal)	lb.	.80	— .85
Beta naphthylamine, sublimed	lb.	2.25	— 2.40
Cresol, U. S. P., in drums (100 lb.)	lb.	.18	— 19
Ortho-cresol, in drums (100 lb.)	lb.	.23	— .25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.15	— 1.20
Cresylic acid, 95-97%, dark, in drums	gal.	1.05	— 1.10
Cresylic acid, 50%, first quality, drums	gal.	.65	— .75
Dichlorbenzol	lb.	.08	— .10
Diethylaniline	lb.	1.50	— 1.60
Dimethylaniline	lb.	.80	— .90
Dinitrobenzol	lb.	.30	— .37
Dinitrochlorbenzol	lb.	.32	— .35
Dinitronaphthaline	lb.	.45	— .55
Dinitrophenol	lb.	.40	— .45
Dinitrotoluol	lb.	–	— .40
Dip oil, 25%, tar acids, car lots, in drums	gal.	.38	— .40
Diphenylamine (nominal)	lb.	.80	— .85
H-acid (nominal)	lb.	2.00	— 2.25
Metaphenylenediamine	lb.	1.25	— 1.30
Monochlorbenzol	lb.	.18	— .20
Monoethylaniline	lb.	2.00	— 2.40
Naphthaline crushed, in bbls. (250 lb.)	lb.	–	—
Naphthaline, flake	lb.	–	— .19
Naphthaline, balls	lb.	–	— .19
Naphthionic acid, crude	lb.	.75	— .85
Nitrobenzol	lb.	.14	— .19
Nitro-naphthaline	lb.	.40	— .50
Nitro-toluol	lb.	.18	— .25
Ortho-amidophenol	lb.	3.25	— 4.25
Ortho-dichlor-benzol	lb.	.15	— .20
Ortho-nitro-phenol	lb.	.80	— .85
Ortho-nitro-toluol	lb.	.25	— .40
Ortho-toluidine	lb.	.30	— .35
Para-amidophenol, base	lb.	2.50	— 3.00
Para-amidophenol, HCl	lb.	2.50	— 3.00
Para-dichlor-benzol	lb.	.08	— .12
Paranitraniline	lb.	1.10	— 1.15

Para-nitro-toluol	lb.	1.35	— 1.50
Paraphenylenediamine	lb.	2.50	— 2 65
Paratoluidine	lb.	2.00	— 2.25
Phthalic anhydride	lb.	.60	— .70
Phenol, U. S. P., drums (dest.), (240 lb.)	lb.	.12	— .20
Pyridin	gal.	2.00	— 3.50
Resorcin, technical	lb.	4.25	— 4.50
Resorcin, pure	lb.	6.25	— 6.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.50	— .52
Salicylic acid, U. S. P.	lb.	.50	— 60
Salol	lb.	.90	— 1.00
Solvent naphtha, water-white, in drums, 100 gal.	gal.	.33½	— .35½
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.23	— .26
Sulphanilic acid, crude	lb.	.32	— .35
Toluidine	lb.	1.70	— 2.50
Toluidine, mixed	lb.	.45	— .55
Toluol, in tank cars	gal.	.35	—
Toluol, in drums	gal.	.38½	— .40½
Xylidine, drums, 100 gal.	gal.	.50	— .65
Xylol, pure, in drums	gal.	.47½	— .50½
Xylol, pure, in tank cars	gal.	.45	—
Xylol, commercial, in drums, 100 gal.	gal.	.32½	— .35½
Xylol, commercial, in tank cars	gal.	.30	—

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark	lb.	$0.36	— $0.39
Beeswax, refined, light	lb.	.37	— .38
Beeswax, white pure	lb.	.63	— .68
Carnauba, No. 1. (nominal)	lb.	.90	— .95
Carnauba, No. 2, regular (nominal)	lb.	.85	— .86
Carnauba, No. 3, North Country	lb.	.35	— 36
Japan	lb.	.17	— .18
Montan, crude	lb.	.25	— .26
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.09	— .09
Paraffine waxes, crude, scale 124-126 m.p.	lb.	.09½	— .10
Paraffine waxes, refined, 118-120 m.p.	lb.	.11	— .11
Paraffine waxes, refined, 125 m.p	lb.	.12½	—
Paraffine waxes, refined, 128-130 m.p.	lb.	.13	— .15
Paraffine waxes, refined, 133-135 m.p.	lb.	.16	— .17
Paraffine waxes, refined, 135-137 m.p.	lb.	.17½	— .18
Stearic acid, single pressed	lb.	.20	— .21
Stearic acid, double pressed	lb.	.22	— .23
Stearic acid, triple pressed	lb.	.24	— .25

NOTE—Paraffine waxes very scarce.

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.946	gal.	$2.15
Pine oil, pure, dest. dist.		1.80
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.85
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.36
Turpentine, crude, sp. gr., 0.900-0.970	gal.	1 75
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.35
Pinewood creosote, ref.	gal.	.52

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$14.60	—
Rosin E-I	280 lb.	14.50	—
Rosin K-N	280 lb.	14.50	—
Rosin G-W. W	280 lb.	14.50	—
Wood rosin, bbl.	280 lb.	15.00	—
Spirits of turpentine	gal.	1.49	—
Wood turpentine, steam dist.	gal.	–	—
Wood turpentine, dest. dist.	gal.	–	—
Pine tar pitch, bbl.	200 lb.	–	— 8.50
Tar, kiln burned, bbl. (500 lb.)	bbl.	14.50	— 15.00
Retort tar, bbl.	500 lb.	15.00	— 15.50
Rosin oil, first run	gal.	.72	—
Rosin oil, second run	gal.	.75	—
Rosin oil, third run	gal.	.92	—

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.40
70-72 deg., steel bbls. (85 lb.)	gal.	.38
68-70 deg., steel bbls. (85 lb.)	gal.	.37
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.29

Crude Rubber

Para—Upriver fine	lb.	$0.29	— $0.31
Upriver coarse	lb.	19	— .20
Upriver caucho ball	lb.	.20	— .22
Plantation—First latex crepe	lb.	.30	—
Ribbed smoked sheets	lb.	.28	—
Brown crepe, thin, clean	lb.	.26	—
Amber crepe No. 1	lb.	.28	—

Oils

VEGETABLE

The following prices are f.o.b., New York for carload lots.

Castor oil, No. 3, in bbls	lb.	$0.16½	— $0.18
Castor oil, AA, in bbls	lb.	.19	—
China wood oil, in bbls (f.o.b. Pac. coast)	lb.	.14½	— .16
Cocoanut oil, Ceylon grade, in bbls	lb.	.15	— .16
Cocoanut oil, Cochin grade, in bbls (nominal)	lb.	.17	— .17
Corn oil, crude, in bbls	lb.	.12	— .13
Cottonseed oil, crude (f.o.b. mill)	lb.	.09	— .11
Cottonseed oil, summer yellow	lb.	.12½	— .13
Cottonseed oil, winter yellow	lb.	.17½	— 18½
Linseed oil, raw, car lots (domestic)	gal.	1.25	—
Linseed oil, raw, tank cars (domestic)	gal.	1.22	—
Linseed oil, boiled, car lots (domestic)	gal.	1.33	—

Olive oil, commercial	gal.	3.00	—	3.10
Palm, Lagos	lb.	.10½	—	...
Palm, bright red	lb.	.10½	—	...
Palm, Niger	lb.	.11	—	.12
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.12¼	—	.12½
Peanut oil, refined, in bbls	lb.	.17	—	.18
Rapeseed oil, refined in bbls	gal.	1.40	—	1.50
Rapeseed oil, blown, in bbls	gal.	1.60	—	1.70
Soya bean oil (Manchurian), in bbls. N. Y.	lb.	.14	—	.14½
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.09½	—	.11

FISH

Winter pressed Menhaden	gal.	$0.90	—	$1.05
Yellow bleached Menhaden	gal.	0.95	—	1.05
White bleached Menhaden	gal.	1.00	—	1.25
Blown Menhaden	gal.	1.00	—	1.20

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	$22.00	—	$25.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	18.00	—	20.00
Barytes, crude, 88%@94% ba., Kings Creek	net ton	8.00	—	10.00
Barytes, ground, white, f.o.b. Cartersville, Ga.	net ton	23.00	—	25.00
Barytes, ground, off-color, f.o.b. Cartersville	net ton	16.00	—	19.00
Barytes, crude, 88%@94% ba., Cartersville	net ton	12.00	—	...
Barytes, floated, f.o.b. St. Louis	net ton	26.50	—	28.00
Barytes, crude, min. 98% ba., Missouri	net ton	11.00	—	11.25
Blanc fixe, dry	lb.	.05½	—	.06
Blanc fixe, pulp	net ton	60.00	—	80.00½
Casein	lb.	.15	—	.18
Chalk, domestic, extra light	lb.	.05	—	.06
Chalk, domestic, light	lb.	.04½	—	.05½
Chalk, domestic, heavy	lb.	.04	—	.05
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.05	—	.06
Chalk, English, dense	lb.	.04½	—	.05
China clay, (Kaolin) crude, f.o.b. mines, Georgia	net ton	9.00	—	12.00
China clay (Kaolin) washed, f.o.b. Georgia	net ton	12.00	—	15.00
China clay (Kaolin) powdered, f.o.b. Georgia	net ton	18.00	—	22.00
China clay (Kaolin) crude f.o.b. Virginia points	net ton	8.00	—	12.00
China clay (Kaolin) ground, f.o.b. Virginia points	net ton	15.00	—	40.00
China clay (Kaolin), imported, lump	net ton	25.00	—	35.00
China clay (Kaolin), imported, powdered	net ton	30.00	—	60.00
Feldspar, crude, f.o.b. Maryland and North Carolina points	gross ton	7.50	—	8.00
Feldspar, crude, f.o.b. Maine	net ton	7.50	—	10.00
Feldspar, ground, f.o.b. Maine	net ton	21.00	—	23.00
Feldspar, ground, f.o. . North Carolina	net ton	17.00	—	20.00
Feldspar, ground, f.o.b. N. Y. State	net ton	17.00	—	20.00
Feldspar, ground, f.o.b. Baltimore	net ton	30.00	—	...
Fuller's earth, granular, f.o.b. Fla.	net ton	25.00	—	...
Fuller's earth, powdered, f.o.b. Fla.	net ton	18.00	—	...
Fuller's earth, imported, powdered	net ton	35.00	—	40.00
Graphite (dust polish grade 30%) Ashland, Ala	lb.	...	—	.01
Graphite (dust facing grade 50%) Ashland, Ala	lb.	...	—	.02
Graphite, crucible, 80%, carbon Ashland, Ala.	lb.	...	—	.05
Graphite, crucible, 90%, carbon Ashland, Ala.	lb.	...	—	.10
Graphite, crucible, 85%, carbon	lb.	...	—	.08
Graphite, crucible, 88%, carbon	lb.	...	—	.09½
Graphite, crucible, 90%, carbon	lb.	...	—	.10½
Pumice stone, imported, lump	lb.	.04	—	.50
Pumice stone, domestic, lump	lb.	.06	—	...
Pumice stone, ground	lb.	.04	—	.07
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton	...	—	10.00
Quartz (acid tower) 1½@2 in., f.o.b. Baltimore	net ton	...	—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore	net ton	...	—	17.00
Quartz, lump, f.o.b. North Carolina	net ton	5.00	—	7.50
Shellac, orange fine	lb.	1.35	—	1.40
Shellac, orange superfine	lb.	1.40	—	1.45
Shellac, A. C. garnet	lb.	1.10	—	1.15
Shellac, T. N	lb.	1.15	—	1.20
Soapstone	ton	15.00	—	25.00
Talc, paper-making grades, f.o.b. Vermont	ton	10.00	—	20.00
Talc, roofing grades, f.o.b. Vermont	ton	9.00	—	15.00
Talc, rubber grades, f.o.b. Vermont	ton	10.00	—	15.00
Talc, powdered, Southern, f.o.b. cars	ton	20.00	—	25.00
Talc, imported	ton	60.00	—	70.00
Talc, California Talcum Powder grade	ton	20.00	—	35.00

Refractories

Chrome brick, f.o.b. Chester, Pa., carlots	net ton	100–	110
Chrome brick, 9-in. strs. and sizes, f.o.b. Baltimore	net ton	100–	105
Fire clay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	55–	60
Fire clay brick, 1st quality, f.o.b. St. Louis	1,000	45–	...
Fire clay brick, 1st quality, f.o.b. New Jersey	1,000	75–	...
Fire clay brick, 2d quality, 9-in. shapes f.o.b. Pennsylvania, Ohio and Kentucky works	1,000	50–	55
Magnesite brick, 9 in. straights, f.o.b. Baltimore	net ton	100	110
Magnesite brick, 9-in. sizes and shapes larger than 9-in.		Regular extras	
Magnesite brick, f.o.b. Chester	net ton	90–	100
Silica brick, 9-in. and 9-in. sizes, Chicago district	1,000	55–	...
Silica brick, f.o.b. Birmingham	1,000	56–	61
Silica brick, f.o.b. Mt. Union, Pa.	1,000	65–	...

Ferro-Alloys

All f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00	—	$250.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon, carlots	lb.	.18	—	.19
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon, carlots	lb.	.20	—	.21
Ferro-manganese, 76-80% Mn, domestic	gross ton	195.00	—	200.00
Ferro-manganese, 76-80% Mn, English	gross ton	170.00	—	175.00
Spiegeleisen, 18-22% Mn	gross ton	75.00	—	...
Ferro-molybdenum, 50-60% Mo, per lb. of Mo.	lb.	2.25	—	2.75
Ferro-silicon, 10-15%	gross ton	60.00	—	65.00
Ferro-silicon, 50%	gross ton	80.00	—	90.00
Ferro-silicon, 75%	gross ton	150.00	—	160.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.10	—	1.15
Ferro-uranium, 35-50% of U, per lb. of U content	lb.	7.00	—	...
Ferro-vanadium, 30-40% per lb. of contained V	lb.	6.50	—	7.75

Ores and Semi-finished Products

All f.o.b. Mines, Unless Otherwise Stated

Bauxite, 52% Al. content, less than 2% Fe₂O₃, up to 20% silica, not more than H4% moisture	gross ton	$10.00	—	$11.00
Chrome ore, Calif. concentrates, 50% min. Cr₂O₃	unit	.60		.65
Chrome ore, 40%, min., Cr₂O₃ f.o.b. Atlantic Seaboard	unit	.77	—	.85
*Coke, foundry, f.o.b. ovens	net ton	20.00	—	...
*Coke, furnace, f.o.b. ovens	net ton	18.00	—	20.00
*Coke, petroleum, refinery, Atlantic Seaboard	net ton	24.00		...
Fluor spar, lump, f.o.b.Tonuco, New Mexico	net ton	17.50		...
Fluor spar, standard, domestic washed gravel Kentucky and Illinois mines	net ton	25.00	—	27.50
Ilmenite, 52% TiO₂, per lb. ore	lb.	.01½	—	85.02
Manganese Ore, 50% Mn, c.i.f. Atlantic seaport	unit	.65	—	.75
Manganese ore, chemical (MnO₂)	gross ton	75.00	—	90.00
Molybdenite, 85% MoS₂, per lb. of MoS₂, N. Y.	lb.	.75	—	.85
Monazite, per unit of ThO₂	unit	42.00	—	...
Pyrites, Spanish, fines ,c.i.f., Atlantic seaport	unit	.12	—	...
Pyrites, Spanish, furnace size, c.i.f., Atlantic seaport	unit	.16½	—	...
Pyrites, Spanish, run of mines, c.i.f., Atlantic seaport	unit	.12	—	.14
Pyrites, domestic, fines	unit	.12	—	.14
Rutile, 95% TiO₂ per lb. ore	lb.	.15	—	...
Tungsten, Scheelite, 60% WO₃ and over, per unit of WO₃	unit	7.00	—	...
Tungsten, Wolframite, 60% WO₃ and over, per unit of WO₃, N. Y. C.	unit	6.00	—	7.00
Uranium Ore (Carnotite) per lb. of U₃O₈	lb.	2.75	—	3.00
Uranium oxide, 96% per lb. contained U₃O₈	lb.	2.75	—	3.00
Vanadium pentoxide, 99%	lb.	12.00	—	14.00
Vanadium Ore, per lb. of V₂O₅ contained	lb.	1.25	—	...
Zircon, washed, iron free	lb.	.10	—	...

*Nominal

Non-Ferrous Metals

New York Markets

		Cents per Lb.
Copper, electrolytic		18.62
Aluminum, 98 to 99 per cent		34.90
Antimony, wholesale lots, Chinese and Japanese		7.00
Nickel, ordinary (Ingot)		43.00
Nickel, electrolytic		45.00
Tin, Straits, spot		48.50
Lead, New York, spot		8.90
Lead, E. St. Louis, spot		8.50@9.00
Zinc, spot, New York		8.50
Zinc, spot, E. St. Louis		7.70@8.05

OTHER METALS

Silver (Commercial)	oz.	$0.99½
Cadmium	lb.	1.40@1.50
Bismuth (500 lb. lots)	lb.	2.70
Cobalt	lb.	3.00
Magnesium (f.o.b. Niagara Falls)	lb.	1.75
Platinum	oz.	115.00@120.00
Iridium	oz.	350.00
Palladium	oz.	100.00@110.00
Mercury	75 lb.	83.00

FINISHED METAL PRODUCTS

	Warehouse Price Cents per Lb.
Copper sheets, hot rolled	33.50
Copper bottoms	38.00
Copper rods	38.00@40.00
High brass wire and sheets	30.25
High brass rods	27.00
Low brass wire and sheets	28.50
Low brass rods	29.00
Brazed brass tubing	38.25
Brazed bronze tubing	41.75
Seamless copper tubing	34.00
Seamless high brass tubing	33.00

SCRAP METALS

	Cents per Lb. Buying Price
Aluminum, cast scrap	20.00@20.50
Aluminum, sheet scrap	20.00@20.50
Copper, heavy machinery comp.	13.50@13.75
Copper, heavy and wire	14.00
Copper, light and bottoms	12.50
Copper, heavy cut and crucible	15.00
Brass, heavy	9.50
Brass, light	7.00
No. 1 clean brass turnings	8.50
No. 1 comp. turnings	12.50@13.50
Lead, tea	5.00
Lead, heavy	7.00
Zinc, scrap	5.00

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by ½ in. and larger, and plates ½ in. and heavier, from jobbers' warehouses in the cities named:

	New York			Cleveland		Chicago	
	Current	One Month Ago	One Year Ago	Current	One Year Ago	Current	One Year Ago
Structural shapes	$4.58	$3.97	$3.47	$5.00	$3.37	$3.97	$3.47
Soft steel bars	4.73	4.12	3.37	4.50	3.27	3.87	3.37
Soft steel bar shapes	4.73	4.12	3.37		3.27	3.87	3.37
Soft steel bands	6.43	5.32	4.07	6.25	3.27		
Plates, ½ to 1 in. thick	4.78	4.17	3.67	4.50	3.57	4.17	3.67

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

PHOENIX — The Arizona Gypsum Co., 213 West Washington St., will build a 2-story gypsum plaster plant. Estimated cost, $40,000. Work will be done by day labor.

Colorado

DENVER—The Concrete Steel Co., 42 B'way, New York City, will build a 1-story, 260x200-ft. steel fabricating shop here. Estimated cost, $200,000. Work will be done by day labor.

Connecticut

SEYMOUR—The Seymour Mfg. Co., 87 Franklin St., has awarded the contract for the construction of a 1-story foundry addition to the H. Wales Lines Co., 134 State St., Meriden. Estimated cost, $25,000.

STAMFORD—Richards & Co., Inc., Ludlow St., has awarded the contract for the construction of a 1- and 3-story factory on Canal and Ludlow Sts. to the J. W. Ferguson Co., 602 West 110th St., New York City. Estimated cost, $75,000.

Florida

KEY WEST—The Bureau of Yards & Docks, Navy Dept., Washington, D. C., plans to build a distillation plant here.

Illinois

CENTRALIA — The Township High School Bd. has awarded the contract for the construction of a 2-story, 130x130-ft. high school to the G. E. Tillman Constr. Co. A chemical laboratory will be installed in same. Estimated cost, $100,000.

EAST ST. LOUIS — The Eagle-Picher Lead Co., Ry. Exch. Bldg., St. Louis, Mo., has awarded the contract for the construction of a factory to the Wimmer Contg. Co., Victoria Bldg., St. Louis, Mo. A chemical laboratory will be installed in same. Estimated cost, $600,000.

EAST ST. LOUIS—The Monsanto Chemical Wks., 1800 South 2d St., St. Louis, Mo., has awarded the contract for the construction of 7 factory buildings to the Wimmer Contg. Co., Victoria Bldg., St. Louis, Mo. Estimated cost, $400,000.

GRANITE CITY — The Bd. Educ. had plans prepared for the construction of a 3-story high school. A chemical laboratory will be installed in same. Estimated cost, $225,000. W. B. Ittner, Bd. Educ. Bldg., St. Louis, Mo., archt. Noted Aug. 4.

HERRIN—The Bd. of Educ. has awarded the contract for the construction of a 2-story, 130x142-ft. high school to P. Cordani. A chemical laboratory will be installed in same. Estimated cost, $123,600. J. W. Kennedy, East St. Louis, archt. and engr.

McLEAN—The Bd. Educ. has awarded the contract for the construction of a 46x102-ft. high school to J. C. Newlin, Bloomington, Ill. A chemical laboratory will be installed in same. Estimated cost, $100,000. J. Howard Baker, secy.

Indiana

INDIANAPOLIS — The Milan Tire & Rubber Co., c/o Myron Wilson, Hotel Cleveland, Cleveland, Ohio, plans to build a 3-story rubber factory. Estimated cost, $350,000. Carter-Richard-Griffith Co., Illuminating Bldg., Cleveland, Ohio, archts. and engrs.

MICHIGAN CITY — The Amer. Iron & Steel Corp. plans to build a 1-story steel plant consisting of a 250-ton blast furnace, 6 open-hearth furnaces and a 12-mill sheet steel plant, etc. Estimated cost, $50,000,-000. L. L. Slick, Engineers' Bldg., Cleveland, Ohio, dir.

PRINCETON — City Council will soon award the contract for the construction of a sewage disposal plant. Estimated cost, $41,850.

Iowa

WATERLOO—The Bd. Educ. has awarded the contract for the construction of a school to H. A. Maine Co. A chemical laboratory will be installed in same. Estimated cost, $600,000.

Kansas

TOPEKA—The city is having plans prepared for the construction of a water purification plant. Estimated cost, $400,000.

Kentucky

LOUISVILLE—The Ewald Iron Co., 224 North Clay St., plans to build an addition to foundry. Estimated cost, $3,000,000. R. B. Hickman, pres.

Maine

BANGOR—The Keyes Fibre Co., Waterville, plans to build a 40-ton capacity, electrically operated mill.

Maryland

BALTIMORE—The Baltimore Brick Co., 708-710 Maryland Trust Bldg., will soon award the contract for the construction of a 1-story brick drier and brick kiln.

BALTIMORE—The Bd. of Awards, c/o City Register, will soon award the contract for the construction of a sludge digestion tank, pipe lines, etc., at the sewage disposal works on the shore of the Back River here. A. E. Christhilf, engr. Noted Aug. 25.

BALTIMORE—The Johns Hopkins University is having plans prepared for the construction of a 2-story chemical laboratory. Estimated cost, $150,000. Carrere & Hastings, 52 Vanderbilt Ave., New York City, engrs.

BALTIMORE — The Prest-O-Lite Co., Inc., 30 East 42d St., New York City, has awarded the contract for the construction of a 1-story, 25x50-ft. acetylene plant in connection with the 8 proposed acetylene buildings here to the West Constr. Co., Foster and 13th Aves. Estimated cost, $75,000. Noted June 23.

Massachusetts

BROCKTON—The city has awarded the contract for the construction of filter beds to the Geo. Howard & Sons Co., 153 Main St. Estimated cost, $155,207. H. S. Crocker, city engr. Noted Sept. 1.

FALMOUTH—The Standard Oil Co. of New York, 50 Congress St., Boston, has awarded the contract for the construction of a 1- and 2-story oil plant to Hardy & Streeter, 95 Milk St., Boston. Estimated cost, $30,000.

HARWICH — The Standard Oil Co. of New York, 50 Congress St., Boston, has awarded the contract for the construction of a 1-story oil plant to Hardy & Streeter, 95 Milk St., Boston. Estimated cost, $30,000.

HYANNIS — The Standard Oil Co. of New York, 50 Congress St., Boston, has awarded the contract for the construction of a 1-story oil plant to Hardy & Streeter, 95 Milk St., Boston. Estimated cost, $35,-000.

NEW BEDFORD—The Sassaquin Sanatorium plans to build a 1-story, 38x70-ft. laboratory here.

SPRINGFIELD — The Forging Service Corp., 318 Main St., will soon award the contract for the construction of a 1-story, 45x125-ft. forge shop on Switzer Ave. Estimated cost, $20,000.

WAKEFIELD—Heywood Bros. and the Wakefield Co., 206 Central St., Gardner, has awarded the contract for the construction of a 1-story factory addition to the Leighton Mitchell Co., 99 Chauncey St., Boston. Estimated cost, $75,000.

WARE — The Ware Coated Paper Co., South St., has awarded the contract for the construction of a 1-story, 70x100 ft. paper factory on Cummings St. to P. H. Provencal, 127 North St. Estimated cost, $40,000.

Michigan

HOUGHTON—The Michigan College of Mines, College Ave., has awarded the contract for the construction of a 2-story chemical building to Herman Gundlach, Leopold Bldg. Estimated cost, $125,000. Noted May 19.

MONROE—The Monroe Auto Equipment Co., East 1st St., plans to build a 1-story, 90x200-ft. foundry. Reed M. Dunbar, archt.

SAGINAW—The American Safety Navigation Co., c/o Managing Secy. Bd. of Commerce, is having plans prepared for the construction of a 1-story factory for the manufacture of aluminum life rafts, etc., and a 6-story office building. This is first unit of a $10,000,000 plant.

Missouri

GRANT CITY—The City Clerk will receive bids until Sept. 21 for the construction of a disposal plant including a Imhoff tank, filtering material, etc. Black & Veach, Mutual Bldg., Kansas City, engrs.

ST. LOUIS—The Bridge & Beach Mfg. Co., 503 South 1st St., has awarded the contract for the construction of 17 buildings on Union and Brown Aves. to the Fruin Colnon Contg. Co., Merchants' Laclede Bldg. A small chemical laboratory will be installed in same. Estimated cost, $800,000.

ST. LOUIS — Lindenwood College, 3715 McCousland St., has awarded the contract for the construction of a 4-story, 104x168 ft. college building to the Sutherland Constr. Co., Syndicate Trust Bldg. A chemical laboratory will be installed in same. Estimated cost, $350,000.

ST. LOUIS—St. John's Hospital, Euclid St. and Parkview Pl., has awarded the contract for the construction of a hospital addition on Euclid St. to the Rodman Bldg. & Constr. Co. A chemical laboratory will be installed in same. Estimated cost, $175,000.

ST. LOUIS—The Magnus Metal Co., 4153 Clayton Ave., has awarded the contract for the construction of a 1-story foundry on present site to the Wimmer Contg. Co., Victoria Bldg. Estimated cost, $60,000.

New Jersey

BRIDGETON — The Illinois Glass Co. plans to build a glass factory. Estimated cost, $3,500,000. Alex. Godfrey, genl. mgr.

NEW BRUNSWICK—The Western Sulphur Co. plans to construct a fertilizer plant. Estimated cost, $150,000. J. G. Lipman, State Agricultural College, pres.

TRENTON — The Luzerne Rubber Co., Muirheid Ave., has awarded the contract for the construction of a 1-story, 60x60-ft. rubber plant on Muirheid Ave. to the Karno Smith Co., Broad St. Estimated cost, $15,000.

TRENTON — The Mutual Pottery Co., Clinton Ave., has awarded the contract for the construction of a pottery plant to Stone & Webster, 120 B'way, New York City. Estimated cost $500,000. Noted May 4.

TRENTON — The Puritan Rubber Mfg. Co., Perrine Ave., plans to construct a 1-story rubber plant. Estimated cost, $7,000.

New York

BROOKLYN—C. A. Benoit, Jerome Ave., will soon award the contract for the construction of a 3-story dye factory on Ave. I. Estimated cost, $200,000.

BUFFALO—Pratt & Lambert, Inc., 79 Tonawanda St., has awarded the contract for the construction of a 4-story, 55x100-ft. factory for the manufacture of varnish to the John W. Cowper Co., Fidelity Bldg. Estimated cost, $75,000.

North Dakota

MARMARTH—The Bd. Educ. will soon award the contract for the construction of a 2-story, 61x91-ft. high school. A chemical laboratory will be installed in same. Estimated cost, $100,000. Noted Aug. 25.

Ohio

BEXLEY (Columbus P. O.) — The city received bid for the construction of an extension to the sewage disposal plant from the Sheets Constr. Co., 1468 Pennsylvania Ave., $5,800.

CHAGRIN FALLS — Ernest McGeorge, engr., 1900 Euclid Ave., Cleveland, will soon award the contract for the construction of a 2-story, 60x120-ft. paper mill addition for the Adams Bag Co., Chagrin Falls. Estimated cost, $100,000. Noted July 7.

CLEVELAND—The Atlantic Fdry. Co., East 75th St. and Morgan Ave., has awarded the contract for the construction of a 1-story, 21x100-ft. foundry addition to the Bolton Pratt Constr. Co., Columbia Bldg. Estimated cost, $10,000.

CLEVELAND—The Bd. Educ. is having plans prepared for the construction of a 3-story high school at Woodland Hills. A chemical laboratory will be installed in same. Estimated cost, $2,000,000. W. R. McCormack, East 6th St. and Rockwell Ave., archt.

CLEVELAND—The Cleveland Camshaft Co., 6520 Carnegie Ave., has awarded the contract for the construction of a 1-story, 39x41-ft. heat treating plant to the Stevens Iron Works Co., 4300 Perkins Ave. Estimated cost, $15,000.

CLEVELAND — The Concrete Steel Co., 42 B'way., New York City, will build a 1-story, 200x200-ft. steel fabricating shop here. Estimated cost, $20,000. Work will be done by day labor.

CLEVELAND — The Concrete Steel Co., Guardian Bldg., plans to build a 1-story, 70x200 ft. factory on Berea Rd. Estimated cost, $75,000. W. Bright, mgr.

CLEVELAND—The A. S. Gilman Co., 623 St. Clair Ave., has awarded the contract for the construction of a 2-story, 90x119-ft. factory addition to the Myers-Kuhn Constr. Co., 210 Metropolitan Bldg. Estimated cost, $50,000.

CLEVELAND—The Natl. Carbon Co., West 117th St. and Madison Ave., plans to build a 1-story factory addition. Estimated cost, $150,000. P. R. Magee, engr.

COLUMBUS—The Capital City Products Co., West First Ave., is having plans prepared for the construction of a 2-story, 100x165-ft. factory addition. Estimated cost, $100,000. Bosset & Trissell, Central Natl. Bank Bldg., archts.

COLUMBIA — The Cleveland Trinidad Paving Co., Grand Theatre Bldg., is having plans prepared for the construction of a 1-story, 100x175-ft. asphalt plant on Dublin Rd. Estimated cost, $60,000.

HOLMESVILLE—The High School Bd. plans to build a 2-story, 63x76-ft. high school. A chemical laboratory will be installed in same. L. E. Crawford, clk.

SPRINGFIELD—The Bd. Educ. will receive bids until Sept. 21 for the construction of a 2-story, 110x128-ft. high school on Maiden Lane. A chemical laboratory will be installed in same. Estimated cost, $225,000. O. D. Himud, 8 East Broad St., Columbus, archt.

Oklahoma

LAWTON—The city has received preliminary report for the construction of a sewage disposal plant and pumping station. Estimated cost, $200,000. V. V. Long & Co., 1300 Concord Bldg., Oklahoma City, consult. engrs.

PURCELL—The city plans an election to vote on $382,000 bonds to construct a filtration plant, etc. Johnson and Benham, Firestone Bldg., Kansas City, Mo., engrs.

STIGLER—The city has received preliminary report for the construction of waterworks extensions including water purification plant, etc. Estimated cost, $35,000. V. V. Long & Co., 1300 Concord Bldg., Oklahoma City, consult. engrs.

Pennsylvania

ERIE—The Bd. Educ. will soon award the contract for the construction of a high school. A chemical laboratory will be installed in same. W. B. Ittner, Bd. Educ. Bldg., archt.

KITTANNING—The Kittanning Iron & Steel Co. is having plans prepared for the construction of a 1-story steel plant addition. Estimated cost, $100,000. Arthur G. McKee Co., 2422 Euclid Ave., Cleveland, Ohio, engrs.

PHILADELPHIA — Rinald Bros., 1142 Hancock St., will soon award the contract for the construction of a 2-story, 46x55-ft. varnish building on Grove and Wharton Sts. Penchert & Wunder, 1415 Locust St., archts. and engrs.

Tennessee

CHATTANOOGA—The Cole Eng. Co. of Philadelphia, Pa., has purchased a site here and plans to build a factory for the manufacture of lubricating steel on same.

CHATTANOOGA — The DuBois Rubber & Tire Co. plans to construct a factory for the manufacture of rubber products.

Texas

DALLAS—The city is having plans prepared for the construction of a water purification plant for the White Rock Reservoir. Estimated cost, $350,000. G. D. Fairtrace, City Hall, engr.

DUBLIN — The Keystone Refining Co. has awarded the contract for furnishing equipment for the proposed refinery here. Estimated cost, $400,000.

Vermont

BELLOWS FALLS—The Liberty Paper Co., Inc., has awarded the contract for the construction of a 3-story factory to the Guarantee Constr. Co., 140 Cedar St., New York City. Estimated cost, $130,000.

HARTFORD — The International Paper Co., 45 Milk St., Boston, Mass., has awarded the contract for the construction of a 2-story paper factory to the H. P. Cummings Constr. Co., 14 Prospect St., Ware, Mass. Estimated cost, $50,000.

Virginia

HAMPTON ROADS—The Bureau Yards & Docks, Navy Dept., Washington, D. C., plans to build a distillation plant here.

MONTPELIER—The School Bd., c/o J. W. Hall, Supt. of Public Schools, Ashland. is in the market for chemical laboratory equipment.

Washington

YAKIMA—The Puritan Rubber Co., 16-17 Wilson Bldg., plans to build a 60x250-ft. factory for the manufacture of tires, tubes, etc. Estimated cost, $250,000. W. L. Lanning, Wilson Bldg., engr.

Wisconsin

BURLINGTON—The city plans to build a sewerage system including a septic tank. Estimated cost, $75,000. C. H. Tubbs, engr.

BUTTERNUT — Edward Ross, Phillips, will soon award the contract for the construction of a 4-story, 60x250-ft. veneer plant on Main St. Estimated cost, $100,000.

FOND DU LAC—The Bd. Educ. will soon award the contract for the construction of a 3-story, 66x260-ft. high and vocational school. A chemical laboratory will be installed in same. Estimated cost, $350,000. Childs & Smith, 64 East Van Buren St., Chicago, archts. Noted July 16.

MILWAUKEE — The Sewerage Comn. plans to build a fine screen building including equipment. Estimated cost, $325,000.

SAUKVILLE — George Suiman & Sons Co., 337 1st St., Milwaukee, has awarded the contract for the construction of a 2½-story, 57x149-ft. leather factory on Main St. to John Schramka, Port Washington. Estimated cost, from $45,000 to $50,000.

SHEBOYGAN — Juul & Smith, archts. Imig Bldg., will soon award the contract for the construction of a 2-story, 70x100-ft. foundry for the Columbia Rubber Mills, 176 16th St., Milwaukee. Estimated cost, from $50,000 to $75,000. Noted Aug. 11.

Wyoming

DOUGLAS—The city voted $75,000 bonds for the construction of a water supply system and filtration plant. Geo. T. Prince, c/o Prince, Nixon Co., Omaha, Neb., consult. engr.

Canada

WELLAND—The Joseph Stokes Rubber Co. has awarded the contract for the construction of a 1-story rubber mill and power plant on Johns and Bernard Sts. to the Karno-Smith Co., Broad St. Bank Bldg., Trenton. Estimated cost, $100,000.

Manitoba

WINNIPEG—The Dominion Oxygen Co. will soon receive bids for the construction of a plant for the manufacture of oxygen for welding purposes. Estimated cost, $100,000.

Nova Scotia

WINDSOR—T. B. Akins, Windsor, and Wright & Jodrey, Wolville, are interested in a company which is having plans prepared for the construction of a small pulp mill, etc. Estimated cost, $250,000.

Ontario

SUDBURY—The International Nickel Co. will soon receive bids for the construction of a rolling mill. Estimated cost, $3,000,000.

NEWMARKET — The city has awarded the contract for the construction of an outfall sewer and activated sludge plant to Currant & Briggs, Orillia. Estimated cost, $34,000. E. A. James Co., Ltd., 36 Toronto St., Toronto, engr. Noted Jan. 7.

PORT ARTHUR—The Provincial Paper Mills, Ltd., of Toronto, plans to construct a paper mill here.

Prince Edward Island

CHARLOTTETOWN—Bruce Stewart & Co. will receive bids for the construction of a 60x120-ft. plant for the manufacture of gasoline engines.

Quebec

ALLARD FALLS—The Manouay Pulp & Paper Co. will soon receive bids for the construction of a plant here. Frank L. Moore, Newton Falls Paper Co., Watertown, N. Y., is interested.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its 1920 meeting Dec. 27, 1920, to Jan. 1, 1921, at Chicago, Ill.

AMERICAN CERAMIC SOCIETY will hold its annual meeting the week of Feb. 21, 1921, at Columbus, Ohio, with headquarters at the Deschler Hotel.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its fall meeting in the Hotel Statler, Cleveland, Ohio, Sept. 30, Oct. 1 and 2.

AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its 1920 convention and exhibit at Columbus, Ohio, the week of Oct. 4.

AMERICAN MINING CONGRESS will hold its next convention in Denver Nov. 15.

AMERICAN PHYSICAL SOCIETY will hold a meeting Nov. 27 at the Case School of Applied Science, Cleveland, and the annual meeting, beginning Dec. 28, at Chicago, the latter being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS' 1920 annual meeting will be held in the Engineering Societies' Building, from Dec. 7 to 10 inclusive.

AMERICAN STEEL TREATERS' SOCIETY, Chicago, will hold its second annual convention and exhibit, combined with the convention of the Steel Treating Research Society of Detroit, Mich., in the Coliseum Museum, Philadelphia, Pa., Sept. 14 to 18 inclusive.

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS will hold its 14th annual convention at the Hotel Pennsylvania, New York City, Sept. 20 to 24, 1920.

THE CHEMICAL WARFARE POST of the American Legion will hold its next meeting Sept. 22, at 8 p.m., in the conference room of the Grand Central Palace, New York City.

ELECTRIC FURNACE ASSOCIATION will hold a meeting Oct. 6, at Columbus, Ohio, the subject of which will be "Refractories."

ENGINEERING COUNCIL will hold its next meeting in Chicago Thursday, Oct. 21, 1920.

INSTITUTE OF METALS DIVISION OF THE A.I.M.E. will hold its usual joint meeting with the American Foundrymen's Association at Columbus, Ohio, during the week beginning Oct. 4.

IRON AND STEEL INSTITUTE (British) will hold its autumn meeting at Cardiff by invitation of the Ironmasters and Steel Manufacturers of South Wales and Monmouthshire. The date of the meeting will be Tuesday, Sept. 21, for the assembling of the members at Cardiff, and the formal proceedings will open on the morning of Wednesday, Sept. 22.

NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES (SIXTH) will be held in the Grand Central Palace, New York City, Sept. 20 to 25.

THE RUBBER SECTION of the National Safety Council will consider safety problems of especial interest to the rubber industry at a section conference to be held Sept. 29 to Oct. 1, in connection with the national session of the Council to be held in Chicago.

SOCIETY OF INDUSTRIAL ENGINEERS will hold its fall national convention at Carnegie Music Hall, Pittsburgh, Pa., Nov. 10, 11 and 12, 1920.